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ATTEMPTS AT INTRODUCING CROWNVETCH (CORONILLA VARIA L.) IN HUNGARY

By

I. Bócsa, J. Krisztián, B. Kadlicskó, A. Máté, I. Késmárki

RESEARCH INSTITUTE OF THE GÖDÖLLŐ UNIVERSITY OF AGRICULTURAL SCIENCES, KOMPOLT;
UNIVERSITY OF AGRICULTURAL SCIENCES, GÖDÖLLŐ;
FACULTY OF AGRONOMY, KESZTHELY UNIVERSITY OF AGRICULTURAL SCIENCES, MOSONMAGYARÓVÁR

The paper gives an account of experiments carried out at 4 sites. Crownvetch and alfalfa grown on chernozem brown forest soil at Kompolt, on brown forest soil with clay illuviation at Demjén, on spoil banks left after surface coal mining at Ecséd and on Danube alluvium with a high lime content at Mosonmagyaróvár, were examined for yield, quality components, rhythm of development, and the proportion of successive cuttings in the total crop. On the basis of the experimental data it can be established that at Kompolt crownvetch yielded 9% less than alfalfa over a 6-year average. The dry matter content was lower, the crude protein content higher, and the raw fibre and carotene contents lower than those of alfalfa. The composition of the amino acids, except for methionine, was the same as in alfalfa. With respect to the rhythm of development and the distribution of yield crownvetch differed considerably from alfalfa, as the first growth represented 72% of the total crop compared to 43% for alfalfa. Over an average of 6 years crownvetch could be cut twice or sometimes three times a year. It was less sensitive to the acidity of soil than alfalfa. The control plots that had not been limed gave twice as large a yield as alfalfa did in the Demjén experiment. Its nutrient demand is also lower; in the Demjén experiment the same volume of yield was obtained with about 200 kg/ha less mixed fertilizer active agent. On the spoil bank with a high lime content at Ecséd the total yield of crownvetch in the third year of the experiment was 71.7% higher than that of alfalfa. In the Mosonmagyaróvár experiment the yield of crownvetch exceeded the alfalfa yield by 29.6% when considering the total crop over 3 years. Of the crownvetch varieties the French variety Louvenours proved significantly better than the other varieties examined. The unequivocally favourable experience gained in the small plot experiments indicates that crownvetch can be successfully planted and grown both on acidic brown forest soils and on alluvial soils and spoil banks poor in nutrients but with a high lime content. On these grounds wide-ranging large-scale trials have been started, at present covering some 500 ha in 30 farms in the northern part of Hungary.

Introduction

It is known that in the United States of America the introduction of crownvetch has been in progress for nearly three decades. The plant was first used to stabilize the banks of the federal highways (Duich 1964), and later to recultivate and bind the soil of spoil banks at surface coal mines, since it is very resistant to water erosion, extremely tolerant to drought, and has no particular nutrient requirements, but has good seed setting (Ruffner 1964, Anonymous 1964, 1968, 1971). Later the species was introduced in field cultivation, after the major questions of planting, chemical weed control, utilization (number of cuttings, grazing), breeding, seed production and feed value had been clarified. In the United States and Southern Canada the species is widely grown; in the United States its production area extends from Maine to Georgia and from the Atlantic to East Dakota (McKee 1971), and three state certified varieties are already in cultivation.

In Europe, despite the fact that it is native here and not in America, it has not been cultivated so far. The reasons for this are unknown, but it is particularly strange because several hundred publications dealing with this plant have appeared so far in the United States, so informations on the favourable experience gained during its cultivation should have been available in Europe for some time. Even at the experimental level only three researchers are known to have determined its feed value and productivity compared to alfalfa: Lenoble—Papineau (1975) in France and Hofbauer (1973, 1977) in Czechoslovakia. The conclusion arrived at in both countries is that crownvetch is a perennial leguminous roughage crop with excellent quality components which under certain ecological and soil conditions is a highly promising addition to the fairly limited choice of leguminous species.

In Hungary preliminary data on the possibility of introducing crownvetch have been published by Bócsa (1974, 1976, 1977). On the basis of the USA data systematic introduction was begun in 1973. In the course of this work all the available French and American varieties were obtained and have been compared with alfalfa on various types of soil. Parallel to this work 0.5 tons of Penngift seed were imported from the United States and used to launch large-scale trials in a number of farms on areas of 1—2 ha each, adapting the successive phases of cultural practices as described in the American literature. Selection was also begun, aimed first at rapid initial growth and faster sprouting, as well as at reduced BNPA β-nitro-propionic acid) content, since this is harmful to monogastric animals.

The present paper is confined to a report on comparative trials with crownvetch and alfalfa species and varieties, and to the responses of the two species to liming and nutrition, and considers the prospects of cultivating crownvetch in Hungary.

Material and methods

The first comparative trial with crownvetch and alfalfa was set up at Kompolt in 1974, on a chernozem brown forest soil with a slightly acidic reaction, with no $CaCO_3$ in the topsoil, a readily available P_2O_5 content and a medium amount of K_2O. The aim was to establish the yield potential of crownvetch compared to alfalfa on this type of soil, and also to study its persistency and determine the optimum spacing, that is, the number of germs per metre and the distance between the rows. Crownvetch was sown in rows at a distance of 20, 30, 40 and 50 cm from one another, with 100 seeds per metre, which corresponds to 20, 12, 10 and 8 kg/ha seed, respectively. The crownvetch variety was Penngift, the alfalfa variety Mv. Synalfa. The plots were arranged in a random block design with five replications; each plot was 12 m^2 in size. The green crop, the dry matter percentage and the crude protein percentage were examined. The data presented refer to 5 years; the trial will be continued until total destruction, so it has not yet been terminated. The number of yearly cuttings is shown in Table 2.

The possibility of cultivating crownvetch was studied on the spoil bank of a surface coal mine at Ecséd, the only favourable feature of which was the large amount of $CaCO_3$ it contained. Apart from this, the readily available mineral nutrients and organic matter content were extremely low. The water conditions were unfavourable, the surface was inclined to crack, and the water conductivity and retention were both poor.

Another comparative crownvetch-alfalfa trial combined with liming and fertilization was set up in the neighbourhood of Demjén, in Heves county, on an eroded sloping area with acidic brown forest soil with clay illuviation, a type of soil characteristic of the Northern Hills in Hungary. The area is on a slope with an 8% southward inclination, moderately damaged by erosion. The soil is more acidic than at Kompolt and contains a smaller amount of readily available nutrients; it is brown forest soil with clay illuviation. Only when limed can it be planted with alfalfa.

In the nursery of the Mosonmagyaróvár faculty of the Keszthely University of Agricultural Sciences the experiment was set up on a calcarous Danube alluvium soil which contained large quantities of $CaCO_3$ and readily available nutrients, and was thus favourable for alfalfa production. Data obtained at this site prove the high potential productivity of crownvetch.

The major characteristics of the soils in the trials described above are contained in Table 1.

The trials at Kompolt, Ecséd and Mosonmagyaróvár were launched in 1974 with uniform fertilizer treatments. The *Coronilla* variety was Penngift at all three sites, while the alfalfa variety was Óvári tarkavirágú at Mosonmagyaróvár and Mv. Synalfa at Ecséd and Demjén. The plot size was 6 m^2 at Ecséd and 5.6 m^2 at Mosonmagyaróvár. The plots in both trials were arranged in a random block design. With the exception of the Kompolt trial the row distance was 30 cm for crownvetch and 20 cm for alfalfa; the number of germs per metre was 100 for crownvetch and 150 for alfalfa.

The trial at Demjén was set up in 1976 in a divided plot design with 4 replications. The treatments are shown in Table 3. The plot size was 30 m^2; the row distance was 10.5 cm for alfalfa with 150 germs per metre and 31.5 cm for crownvetch with 75 germs/m.

In addition to the green crop the dry matter content and the crude protein percentage were measured in each experiment; in certain experiments the raw fibre and carotene contents were also determined, and in the Kompolt and Mosonmagyaróvár trials an aminogram was also prepared for crownvetch. The determination of the amino acid composition in the Kompolt trial was carried out by the National Inspectorate of Animal Husbandry and Feeding.

Finally, in 1976 a comparative variety trial was set up at Kompolt from the assortment at our disposal, which at the same time served to supply information for the National Institute for Variety Testing (OMFI), since the latter did not launch national trials for this purpose, but agreed instead to accept our data. The experiment included the following varieties:

1. Kompolti C_6 (Hungarian, selected from Penngift)
2. Louvenours (French, selected from local ecotypes)

Table 1

Results of soil analysis at the experimental sites

	pH		$CaCO_3$, %	y_1	P_2O_5, mg%	K_2O, mg%	Organic matter, %
	H_2O	KCl					
Kompolt	6.5	5.2	0	9.5	3	16	2.9
Demjén	6.1	4.8	0	11.4	1	9	2.5
Mosonmagyaróvár	8.4	7.8	12	—	13	12	2.8
Ecséd*	4.8	7.1	15	—	2	8	0.9

The P_2O_5 and K_2O mg% values were obtained in aluminium lactate solution.
* Analytical result of a spoil bank left after surface coal mining.

Table 2

Number of cuttings, proportion of first growth to the total crop, and green yield at Kompolt in 1974–1979

Species	1974	1975	1976	1977	1978	1979	Average
			Number of cuttings				
Alfalfa	2	4	4	4	3	3	3.3
Crownvetch	1	3	2	2	2	2	2.0
			Proportion of first growth to total crop, %				
Alfalfa	—	43.0	56.5	44.5	45.5	54.0	48.7
Crownvetch	—	72.5	81.0	79.5	71.5	58.0	72.5
			Green crop				
Alfalfa, ton/ha	19.0	61.6	44.3	78.0	49.9	33.6	
%	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Crownvetch, ton/ha	16.4	67.0	34.7	46.4	66.3	29.9	
%	83.9	108.8	78.3	59.5	132.8	88.9	90.9
$LSD_{5\%}$							8.5

Table 3

Treatments at Demjén

Species "A" (1)	Liming "B" (2)	Fertilization "C" (2)
Crownvetch	Ca_1	$M_1 - M_2 - M_3 - M_4$
	Ca_2	$M_1 - M_2 - M_3 - M_4$
Alfalfa	Ca_1	$M_1 - M_2 - M_3 - M_4$
	Ca_2	$M_1 - M_2 - M_3 - M_4$

Ca_1 = 4.5 ton/ha ground limestone
Ca_2 = 9.0 ton/ha ground limestone
$M_1 = N_0\ P_0\ K_0$
M_2 = 35 kg/ha N + 80 kg/ha P_2O_5 + 90 kg/ha K_2O
M_3 = 70 kg/ha N + 160 kg/ha P_2O_5 + 180 kg/ha K_2O
M_4 = 105 kg/ha N + 240 kg/ha P_2O_5 + 270 kg/ha K_2O
Plot size: 30 m^2

3. Penngift (USA, state certified variety)
4. Keszthelyi (Hungarian, of American origin)
5. Vertibenda, alfalfa (control)
6. Szarvasi-1, alfalfa (control).

The trial was laid out on a soil type similar to that in the comparative variety trial planted at Kompolt in 1974 (see Table 1).

The plots were sown at a uniform row distance of 20 cm with 100 germs per metre, in a random block design with 5 replications. The plot size was 12 m^2. The investigations lasted for a total of 4 years. The crownvetch varieties were cut once in the year of planting and twice in the other years; the alfalfa (control) varieties were cut twice in the year of planting and three or four times in each of the subsequent years. The varieties were examined for green crop, dry matter and crude protein percentage.

Results

Data on the yields and components in the 6-year row-distance experiment at Kompolt are shown in Tables 2 and 4.

As seen in the tables the average number of yearly cuttings was 2 for crownvetch, and somewhat more than 3 for alfalfa, over a 6-year average. Accordingly crownvetch differed considerably from alfalfa with respect to the distribution of yield, since over an average of 6 years 72.5% of the total annual crop of crownvetch came from the first cutting and only 27.5% from the second growth. The first cutting of crownvetch yielded 55.3% more than the first growth of alfalfa over a 6-year average, a fact which has certain consequences as regards mechanization and labour organization in the course of harvesting.

Crownvetch became ripe for cutting in the first ten days of June over an average of 6 years; this is in fact the beginning of flowering (some 10—20% flowering). The flowering period is 4 – 6 weeks long, so it is almost impossible to determine the date of "full blossom" for crownvetch, as is usual for alfalfa. Hence, it is advisable for cutting to take place in early blossom, i.e. 8—10 days after the appearance of the first flowers.

As regards the yield, in two of the 6 years (1975 and 1978) crownvetch was far superior to alfalfa; in the other years alfalfa gave significantly larger yields. All in all, on the prevailing soil type at Kompolt *Coronilla* only yielded 9% less than alfalfa, which is about the margin of significance. On soil not particularly suitable for alfalfa (high dead water capacity, low water retention, poor nutrient availability, deep ground water level, etc.) the yield potential of crownvetch is noteworthy. Since the first growth becomes ripe for cutting a month later than that of alfalfa, on such soils it can be used to extend the harvesting and grazing periods, or for silaging, thus avoiding the spring work peak.

Since the yields obtained with different row distances and seeding rates, are unimportant from the point of view of comparing the two species, they are not numerically presented here. It is nevertheless worth mentioning that there were no significant differences between the yields obtained with 20, 30 and 40 cm distances between rows, and 20, 13 and 10 kg/ha seed. Statistically significant differences in yield were only found when the 8 kg/ha (50 cm) treatment was compared with the 20 and 13 kg/ha treatments. However, the recommended amount of seed is 20 kg/ha, as closed stands can only be expected at relatively high seed rates because of the slow initial development and the slow and protracted germination caused by hard-coatedness.

As shown in Table 4, the dry matter content of crownvetch is somewhat lower, while its crude protein content is higher compared to alfalfa, so the crude protein production of the two species is more or less identical. The lower raw fibre content is an advantage of crownvetch, while for carotene content alfalfa is superior.

Table 4

Major components of alfalfa and crownvetch
(average over all trials)

Species	Dry matter	Crude protein	Raw fibre	Carotene, mg/kg
	%			
Alfalfa	26.4	19.1	20.4	142
Crownvetch	25.5	20.0	17.5	119

Table 5

Comparative analysis of amino acids in alfalfa and crownvetch
(g/100 g)

Amino acid	Crownvetch		Alfalfa (after BOLTON 1962)
	Kompolt	Mosonmagyaróvár	
Alanine	5.37	5.27	7.50
Arginine	4.81	4.77	4.60
Asparagic acid	18.31	12.43	15.60
Glutamic acid	13.31	9.64	8.70
Glycine	5.19	4.92	4.60
Histidine	2.06	1.99	2.30
Leucine	7.69	9.89	7.50
Isoleucine	4.13	4.32	5.20
Lysine	5.50	4.62	6.40
Methionine	0.63	0.45	1.20
Phenylalanine	4.56	4.42	4.60
Proline	5.56	4.57	5.80
Serine	4.63	3.83	4.60
Threonine	4.06	3.88	5.20
Tyrosine	2.50	2.83	2.90
Valine	5.38	4.62	4.60
Crude protein, %	16.00	20.12	

Table 6

Comparative trial of crownvetch and alfalfa for green yield
(Ecséd, 1974—1976)

	1974		1975		1976		1974—1976	
	yield t/ha	%	yield, t/ha	%	yield, t/ha	%	yield, t/ha	%
				Crownvetch				
1st cutting	16.8	—	63.5	85.3	22.3	79.1	102.6	85.9
2nd cutting	—	—	10.9	14.7	5.9	20.9	16.8	14.1
Total	16.8	—	74.4	100.0	28.2	100.0	119.4	100.0
Rel. number	390.7		171.8		127.0		171.1	
				Alfalfa				
1st cutting	4.3	—	21.7	50.1	9.8	44.2	35.8	51.2
2nd cutting	—	—	13.3	30.7	5.8	26.1	19.1	27.4
3rd cutting	—	—	6.3	14.6	6.6	29.7	12.9	18.5
4th cutting	—	—	2.0	4.6	—	—	2.0	2.9
Total	4.3		43.3	100.0	22.2	100.0	69.8	100.0
Rel. number	100.0		100.0		100.0		100.0	
$LSD_{5\%}$	2.5		14.5		non-sign.		19.9	

The results of amino acid analyses are seen in Table 5. As far as we known no data has so far been published on the amino acid content of crownvetch. The data of amino acid analyses made in two different laboratories show a close agreement. Crownvetch only differs from alfalfa in its lower methionine content; as regards the other amino acids the two species can be regarded as identical. Since this was the first case of amino acid determination the data in BOLTON's (1962) hand-book, which represent the average of several hundreds of alfalfa amino acid analyses, were taken as the basis of comparison rather than those obtained from our own experiments.

The results of the Ecséd trial are presented in Table 6. On the spoil bank of the surface coal mine at Ecséd crownvetch yielded 71.7% more than alfalfa over three years. It was chiefly in the year of planting, and then in the second year that the difference was particularly great in favour of crownvetch, though even in the third year crownvetch gave a 27% larger yield than alfalfa.

In the first year of the trial at Demjén neither plant gave a measurable yield owing to the droughty weather. The data of Table 7 are the production results of the 2nd—3rd and 4th years.

Although no significant difference is found between the yields of the two plants (factor "A"), it is nevertheless worth noting that on this eroded

Table 7

Total green crops of crownvetch and alfalfa in 1976—1979 at Demjén

Ground limestone, t/ha	Fertilizer active agent			Yield	
	N	P_2O_5	K_2O	crownvetch	alfalfa
	kg/ha			t/ha	
(1)	(2)			(3)	(4)
4.5	∅	∅	∅	43.1	23.6
4.5	35	80	90	97.9	76.9
4.5	70	160	180	109.7	98.7
4.5	105	240	270	108.4	125.5
9.0	∅	∅	∅	56.7	30.3
9.0	35	80	90	97.8	103.7
9.0	70	160	180	113.2	125.5
9.0	105	240	270	123.3	121.5

"B" Liming $LSD_{5\%}$ 11.3 t/ha
"C" Fertilization $LSD_{5\%}$ 7.9 t/ha

Table 8

Comparative trial of crownvetch and alfalfa for green crop
(Mosonmagyaróvár, 1974—1976)

	1974		1975		1976		1974—1976	
	yield, t/ha	%	yield, t/ha	%	yield, t/ha	%	yield, t/ha	%
				Crownvetch				
1st cutting	20.2	100.0	48.9	47.4	39.9	77.0	109.0	62.2
2nd cutting	—		42.3	40.9	11.9	23.0	54.2	30.9
3rd cutting	—		4.7	4.6	—		4.7	2.7
4th cutting	—		7.3	7.1	—		7.3	4.2
Total	20.2	100.0	103.2	100.0	51.8	100.0	175.2	100.0
Rel. number	113.5		152.0		104.7		129.6	
				Alfalfa				
1st cutting	8.1	45.5	23.6	34.8	43.9	88.7	75.6	55.9
2nd cutting	9.7	54.5	22.7	33.4	5.6	11.3	38.0	28.1
3rd cutting	—		14.7	21.6	—		14.7	10.9
4th cutting	—		6.9	10.2	—		6.9	5.1
Total	17.8	100.0	67.9	100.0	49.5	100.0	135.2	100.0
Rel. number	100.0		100.0		100.0		100.0	
$LSD_{5\%}$	0.1		23.9		non-sign.		25.7	

area, poorly supplied with nutrients, crownvetch produced larger yields in the unfertilized control and in plots given only a small amount of fertilizer.

The experiment confirmed the low sensitivity of *Coronilla* to the acidity of the soil. In plots given no fertilizer the yield of crownvetch was reliably increased by 4.5 ton/ha ground limestone. At an optimum level of nutrition the smaller dose (4.5 ton/ha) of limestone proved sufficient. The yield of alfalfa, on the other hand, was higher in every case (with the exception of the highest rate of fertilization) in plots supplied with 9.0 ton/ha of ground limestone.

On the basis of the experimental data it can be stated that crownvetch can be successfully planted and grown on acidic brown forest soils. The annual dry matter yield of 10–11 ton/ha obtained at an adequate level of nutrition (430 kg mixed fertilizer active agent in the present case) suggests that Coronilla is a valuable fodder plant. Similar yields were only obtained with alfalfa following the application of 615 kg/ha fertilizer active agent.

In the Mosonmagyaróvár trial the yield of crownvetch was 29.6% higher than the alfalfa yield over an average of 3 years (Table 8). Crownvetch produced larger yields than alfalfa in all three experimental years; the difference in favour of crownvetch was particularly great in the second year, when it yielded 50% more. In the second year, and in the total crop of the third year the yield of crownvetch showed a statistically significant difference. The yield distribution was different in this trial than in the other trials; the joint yields of the first and second growths made up 93% of the total yield for crownvetch and 84% for alfalfa. This means that at Mosonmagyaróvár, as a response to the rainier climate, crownvetch was cut more than twice in some years; in fact, in 1975 it developed a small fourth growth. At the same time, in the other trials crownvetch only produced two growths a year over the average of several years.

The results of the comparative variety trial are summed up in Table 9. The table shows that the French variety Louvenours gave significantly larger yields than either Penngift or Kompolti C_6. The variety Keszthelyi occupies an intermediate position, not significantly differing from the other varieties except for Penngift. At the same time, Louvenours, Keszthelyi and Kompolti C_6 can be regarded as equal in productivity to the two control alfalfa varieties (considering the average yield of the latter), while only Penngift was found to be significantly less productive.

At present, variety would seem to be of secondary importance when considering the introduction of crownvetch on a large scale. The first step is to exploit the yield potential inherent in the species wherever the physico-chemical properties, slope and water conditions of the soil are not suitable for alfalfa production. Hundreds and thousands of hectares of areas exposed to erosion are found in the Northern chain of hills, stretching from the Bakony to

Table 9

Green yields of crownvetch and alfalfa varieties in 1976—1979

	Green yield									
	1976		1977		1978		1979		Average	
	t/ha	%	t/ha	%	t/ha	%	t/ha	%	t/ha	%
					Crownvetch					
Kompolti C_6	17.59	66.04	45.61	70.1	56.46	137.3	28.61	95.3	37.07	91.07
Louvenours	20.56	77.17	44.18	67.9	64.63	157.1	35.48	118.2	41.21	101.24
Penngift	19.14	71.85	32.88	50.5	56.96	138.5	31.51	105.0	35.12	86.28
Keszthelyi	17.79	66.79	43.23	66.4	65.13	158.4	31.76	105.8	39.48	96.99
					Alfalfa					
Szarvasi-1	27.14		64.98		37.69		29.09		39.73	
		100.0		100.0		100.0		100.0		100.0
Vertibenda	26.14		65.14		44.53		30.89		41.68	
$LSD_{5\%}$									*4.09*	*10.04*

the Zemplén Hills. The trial sowing of plots of 10—20 ha began in 1977, and in 1980 the behaviour of this new valuable leguminous fodder crop under farm conditions can be judged on a total of around 500 ha.

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VARIA

REGULATION OF THE DEVELOPMENT OF WINTER WHEAT VARIETIES USING LONG AND SHORT DAY ILLUMINATION

In the institute's wheat breeding programme crossing has been transferred from the field to the phytotron, where it is possible to raise four generations a year. In a controlled environment varieties of different origin and with different vegetation periods show even greater differences in flowering time than in the field. So their development must be regulated to achieve nicking in the flowering time combined with the highest possible number of grains. In the first part of the investigation the effect of illumination period on the development of the vegetation period (heading) was studied.

Scientists have long since observed that light has an effect on plant growth (DE CANDOLLE 1832, BONNIER 1895). TOURNOIS (1912) discovered the positive effect of short day on hops and KLEBS (1918) of long day on *Sempervivum*. BLAAUW (1918) established the fact that the same illumination accelerated the development of some plant species and retarded that of others.

Similar research on wheat began after GARNER—ALLARD (1920) discovered the phenomenon of photoperiodism. Since then many authors have dealt with numerous problems of wheat photoperiodism, but the adequate light response necessary for the exact regulation of development has not yet been determined.

The investigations were carried out in the phytotron at the Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvásár. Three types of illumination were used to study the regulation (retardation, acceleration) of development: short day (10 hours), normal day (16 hours) and long day (22 hours). The illumination was provided by Gro-Lux/WS and Cool White fluorescent tubes with an intensity of 20—25 thousand lux (400 μE/m^2/sec). The temperature varied between 15—16 °C and 18—24 °C from planting to maturity.

Three wheat varieties of various origin and with different vegetation periods were chosen for the investigations:

Sadovo 1: a winter hardy, early variety of southern origin.
Pedigree: Jubileinaya III $\times$ Bezostaya 1.
Bred at Sadovo, Bulgaria.

Bezostaya 1: a winter hardy, midseason variety introduced into Hungary.
Pedigree: Lutescens 17 $\times$ Skorospelka 2.
Bred at Krasnodar, Soviet Union.

Maris Huntsman: a winter hardy, late variety of northern origin.
Pedigree: (CI 12633 $\times$ Capelle D.$_5$) $\times$ Hyb 46 $\times$ (Capelle D. $\times$ Prof. Marchal$_2$).
Bred at Cambridge, England.

The seeds of these varieties were germinated in Petri dishes, then planted in plastic tubes and vernalised for 45 days in the seedling stage in a chamber at 2 °C under weak blue illumination. The plants were then transferred to pots and placed in a phytotron (GB) chamber, where they were raised on the normal programme devised by S. and E. Rajki (for details, see Balla 1980). The treatments were based on the Feekes scale of development. When plants raised on the normal programme reached the required stage of development they were transferred to another chamber (E 15 VH) with identical temperature but with short or long day illumination. The plants were kept there until they had completed the given developmental phase.

The treatments can be divided into three groups:

1. Treatment over two phases of development (1—2, 3—4, 5—6, 7—8 or 9—10.1).
2. Treatment over four phases of development (1—4 or 5—8).
3. Treatment from planting to heading (1—10.1).
4. Control, raised under normal illumination.

Ten plants were included in each treatment. The effect of light on the length of the vegetation period was determined by observing the heading date. The plants were kept under observation for 99 days, after which the examination was terminated.

As a result of twice daily watering and a regular supply of nutrients 2.5—3.5 normally sized ears were obtained on average on each plant.

The illumination treatments applied during various phases of development had different effects on the varieties (Table 1).

Under normal (16 hours) illumination Sadovo 1 headed on the 50th day after planting. If this variety was raised under short day illumination during developmental phases 1—2 or 5—6 the development was retarded and the plants headed 4 or 6 days, respectively, later than the control. Treatment during phases 3—4, 7—8 or 9—10.1 proved ineffective. The retardation of the development was greater if the treatment was carried out in developmental phases 1—4 or 5—8, while the effect was greatest if the plants were raised under short day illumination from planting to heading.

Table 1

Number of days from planting to heading under short and long day illumination (2-year average)

Developmental phase	Length of treatment days	Sadovo 1		Length of treatment days	Bezostaya 1		Length of treatment days	Maris Huntsman	
		short	long		short	long		short	long
1—2	12	54	44	12	61	56	12	67	67
3—4	4	50	48	4	59	54	6	72	65
5—6	15	56	42	18	64	53	25	85	57
7—8	6	51	47	8	60	56	12	78	66
9—10.1	14	52	49	19	58	56	25	78	65
1—4	19	56	43	19	64	53	18	70	65
5—8	22	57	43	22	68	52	56	+	55
1—10.1	74	74	37	81	81	48	25	+	50
Control (normal illumination 1—10.1)		50			56			67	

+ Did not head

Table 2

Effect of illumination during different stages of development on wheat heading (in days)

Treatment in phase	Effect of one hour's illumination in days		
	Sadovo 1	Bezostaya 1	Maris Huntsman
1–2	0.67	0.58	0.42
3–4	0.33	0.17	1.17
5–6	1.08	1.08	2.92
7–8	0.17	0.33	1.42
9–10.1	0.42	0.08	1.00
1–4	1.08	1.17	0.83
5–8	1.33	1.33	—

The development-accelerating effect of long day (22 hours) illumination found expression in practically every treatment. But it was only significant when the treatment was carried out in phases 1—2, 5—6, 1—4 or 5—8. (The LSD in the experiments was 2—2.5 days, so differences smaller than this could not be taken into consideration.) Naturally, in this case too, the development was most rapid when the treatment was continued throughout all the developmental phases.

Bezostaya 1 responded more intensely to short than to long day illumination. Significant retardation was observed when the treatment was carried out in phases 1—2, 5—6, 7—8, 1—4 or 5—8. Treatment in phases 5—8 resulted in a 12-day delay in heading, and continual short day illumination in a 25-day delay. A significant shortening of the vegetation due to long day illumination was observed when the treatment was carried out in developmental phases 5—6, 1—4 or 5—8. Continual long day illumination brought heading forward by 8 days.

Maris Huntsman, which is of northern origin and has a long vegetation period, responded even more intensely than Bezostaya 1 to short day illumination. The effect was greater if the treatment was carried out in the later phases of vegetative growth. It is interesting to note that this variety did not respond to short day illumination in developmental phases 1—2. If the treatment was carried out in phases 3—4 or 5—6 the plants headed 5 or 8 days later, respectively, than under normal illumination. Treatments applied in phases 7—8 or 9—10.1 also had a significant effect (11-day delay). Treatment in phases 1—4 was not very effective in Maris Huntsman, but if the treatment was applied throughout phases 5—8 the plants failed to head. It was thus not surprising that there was no heading when the short day illumination was carried out throughout the vegetation period.

This variety generally responded poorly to long day illumination. The development was only accelerated by treatment in phases 5—6 or 5—8, when heading was 10 or 12 days earlier, respectively, than in the control. Heading occurred earliest (17 days earlier than the control) when long day illumination was applied from planting to heading.

It can thus be established from the data that it is easier to accelerate than to retard the development of Sadovo 1, which is of southern origin and has a short vegetation period, but easier to retard than to accelerate that of Maris Huntsman, which is of northern origin with a long vegetation period. However, this tendency does not help in achieving nicking in the flowering time.

The development of wheat cannot be significantly influenced by treatment carried out in two developmental phases. It seems preferable to continue the treatment for 4 developmental phases. Consequently, the effect of treatment in phases 1—4 and 5—8 is analysed in detail in Figs 1 and 2.

The effect of treatment in developmental phase 1—4 proved to be linear for all three varieties (Fig. 1). The regression line was steepest for Sadovo 1 and flattest for Maris Huntsman, but the three types of illumination are not sufficient to produce nicking in the flowering of early and late varieties when applied during this stage of wheat development.

Figure 2, which illustrates the effect of treatment in developmental phases 5—8, is more interesting. In these phases too, there is a linear correlation between heading and the illumination period for Sadovo 1, but for Maris Huntsman and Bezostaya 1 this correlation is expressed by a hyperbola. This figure again shows that the development-retarding effect of short day is most intensive for the late variety Maris Huntsman. Bezostaya 1 is intermediate between the early and late varieties.

The data and the figures lead to the conclusion that nicking in the flowering times of different varieties can be successfully brought about by treatment in developmental phases 5—8. The correct treatment can be selected by observing at what points the regression lines of the three varieties intersect an imaginary line drawn parallel to the horizontal axis. The points of intersection indicate the required daylength for raising the individual varieties and the common heading date. For example, the three varieties tested in these investigations will all head on the 58th day after planting if Sadovo 1 is given 9-hour, Bezostaya 1 16-hour and Maris Huntsman 21-hour illumination during developmental phases 5—8.

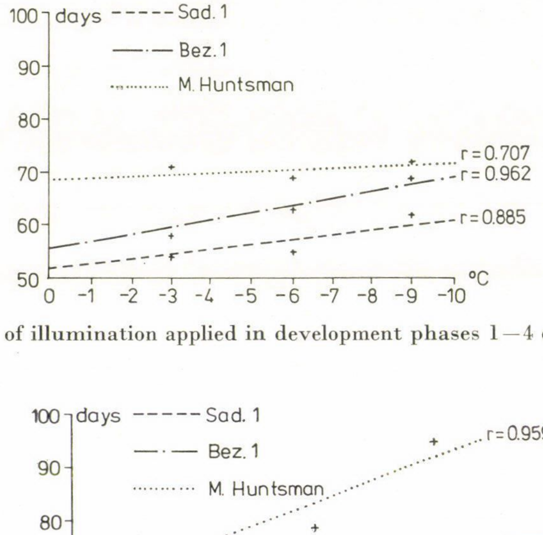

Fig. 1. Effect of illumination applied in development phases 1—4 on heading date

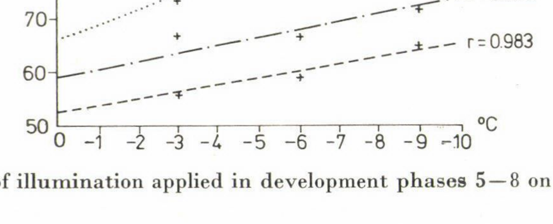

Fig. 2. Effect of illumination applied in development phases 5—8 on heading date

The data also served to demonstrate the efficiency of treatment in various phases of development. In other words, how sensitive wheat is to treatment during different developmental phases. The results are shown in Table 2, which indicates that if the illumination period is reduced or increased by an hour in developmental phases 5—6 the heading date of Sadovo 1 and Bezostaya is modified on average by 1.08 days and that of Maris Huntsman by 2.92 days. The effect is more intense if the treatment is continued throughout phases 5—8. A knowledge of these data enables the breeder to regulate the vegetation period of wheat varieties at will and to achieve nicking in the flowering times of early and late varieties.

However, crossing will only be successful if the seed setting is satisfactory. The day-length can only be changed as long as it is not detrimental to seed setting. This aspect will be considered in another paper in this series.

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Prepared at the Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvásár

L. Balla

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Cd AND Cu CONTENTS OF CERTAIN ORGANS IN COWS

Cadmium is a component of zinc ores, but also occurs in other raw materials not of the iron ore type. Its boiling point is lower than that of zinc and of other metals of non-iron ore character, so it is released in the metallurgical process and pollutes the environment. Cadmium is used in many industries, e.g. in paint and dye factories (cadmium sulphate is a paint known as cadmium yellow), for galvanization, in producing alloys, in manufacturing television tubes, for fungicides, as a plastics stabilizer, etc. For this very reason numerous everyday articles contain cadmium. Some one-third of the cadmium produced and utilized has entered the environment, and thus, through industrial and urban sewage, refuse and compost, has entered various plants, since these materials are used in part as fertilizers

(FRIEBERG *et al.* 1974). Fuels and phosphorus fertilizers also contain some of this harmful element.

Acute and chronic Cd-toxicoses in men employed in zinc production were already known at the end of the last century (TRACINSKY 1888), although the harmful effect of cadmium had not yet been recognized. The toxicity of cadmium-containing dust or Cd-salts has been repeatedly discussed (PRODAN 1932, NICAUD *et al.* 1942, FRIEBERG 1950, AHLMARK *et al.* 1960, KAZANTZIS *et al.* 1963, BETON *et al.* 1966, PISCATOR 1966, TSUCHYA 1966), without it being possible for intermediary metabolic disturbances to be studied. Acute cadmium toxicosis is, in fact, easy to check and diagnose, since it mainly occurs in zinc mines, zinc metallurgy and smaller chemical and metallurgical works.

Foodstuffs and animal feed may contain different quantities of cadmium depending on the geological origin of the soil, the kind of feed or food, and possibly on the extent of industrial contamination. A large proportion of the cadmium introduced into human or animal organisms is not excreted but accumulates and, according to recent investigations, may be a concomitant of heart and lung diseases (ANKE—SCHNEIDER 1974, MILLER 1971).

ANKE *et al.* (1975) demonstrated that under the influence of cadmium the feed intake and weight gain decreased, female animals aborted and the sperms of male animals were infertile. Cadmium accumulates primarily in the kidneys, liver, ovaries, spleen and lungs. Cadmium reduces the zinc content in the organs, except in the kidneys and liver, where it can be stored in larger quantities. A copper deficiency also occurs, which in fact explains the deaths of foetuses from parents given cadmium supplements (ANKE *et al.* 1977).

Animal species give different responses to cadmium; the cadmium content in the different organs varies with age and sex. Kidneys, liver and hair can best be used for demonstrating the amount of cadmium stored in the organism (REGIUS-MŐCSÉNYI—SZENTMIHÁLYI 1977). Since cadmium in the organism has an inhibitory effect on the zinc and copper transportation systems, cadmium stress may lead to secondary zinc and copper deficiencies, and thus to considerable production losses (ANKE 1973, ANKE *et al.* 1976).

The cadmium contents of the kidneys and liver give the most accurate information about the extent of cadmium stress in the organism (NOMIYAMA *et al.* 1977). The discharge of cadmium from the organism is a slow process and the cadmium content gradually increases in the organs, so the organs of long-lived animals are suitable for investigating the extent of the detrimental effect of cadmium.

The data presented in this paper refer to the neutral loess and grassland soils which are the most characteristic of fodder crop production in Hungary. The organs of 45 cows, all more than 9-year-old and sent to the slaughter house from 4 different places were examined. The effect of fodder plants grown in industrially contaminated areas on the cadmium content of the different organs is not reflected in the present data. A survey of these areas and the extension of investigations of this kind to cover the whole country are projected in the future.

Cadmium and copper were determined by atom absorption spectrophotometry after reduction to ashes at 450 °C; the values are given on a dry matter basis.

The cadmium contents of the organs examined were generally low compared to the literary data (ANKE *et al.* 1977). GERGELY—LINDNER-SZOTYORI (1977) also found less cadmium in baby foods produced in Hungary (0.62—0.75 mg/kg) than in those imported from abroad (0.4—1.20 mg/kg). ANKE *et al.* (1977) found 5.5 ppm cadmium in the kidneys of cows aged about 6 years old in the GDR compared to an average cadmium content of 3.1 ppm in Hungary, although the animals examined here were almost twice as old. The cadmium contents of the liver, cerebrum, costal bone and hair were nearly identical in cows examined in the two countries (Table 1).

Similar results were obtained when grouping by site of origin. The cadmium content of the liver only shows a slight change; the differences are random. The highest origin-

Table 1

Cadmium contents (in ppm) in organs of cows aged over 9-year-old
(n = 45)

	Kidneys	Liver	Cerebrum	Costal bone	Hair
$\bar{x}$	3.1	0.74	0.12	0.02	0.01
s	1.6	0.51	0.04	0.05	0.007

Table 2

Cadmium contents (in ppm) in kidneys of cows from different areas

	1 (n 9)	2 (n 12)	3 (n 15)	4 (n 9)
$\bar{x}$	4.0	3.8	2.5	2.2
s	1.8	2.4	1.2	1.58

Table 3

Cadmium contents (in ppm) in livers of cows from different areas
(n = 45)

	1 (n 9)	2 (n 12)	3 (n 15)	4 (n 9)
$\bar{x}$	0.80	0.63	0.90	0.55
s	0.24	0.41	0.89	0.28

dependent average value was 4.0 ppm and the maximum 7.2 ppm for the whole kidney. This relatively large amount of cadmium, compared to the average, was found in an 11-year-old cow from an alluvium soil of grassland character near the Danube. Anke *et al.* (1977) demonstrated as much as 32—116 ppm cadmium in the kidneys of animals from an area where coloured metallurgy was carried out. Cadmium values of this order have not been found so far in Hungary either in individuals or on an average (Table 2).

The cadmium content of the liver confirmed the above results: the average cadmium content of all the examined livers was below 1.0 ppm. From the available data it can be concluded that the cadmium stress is extremely low in Hungary, especially considering that the average age of the cows examined in the literary data (Anke *et al.* 1977) was about 6 years, while the animals analysed in Hungary were 10 years old on average. Since the amount of cadmium stored in the organs increases parallel to the age, this result is worthy of special attention (Table 3).

For the sake of comparison the organs were analysed for copper content. Values indicative of clinical symptoms of copper deficiency — below 15 ppm in the liver and less than 6 ppm in the cerebrum — were found only in one animal (12 ppm copper in the liver and 5.6 ppm in the cerebrum). This was probably an analytical error, since all the other values were much higher (Table 4). It must be noted, however, that in the same organ lower copper contents were found in combination with higher cadmium levels and vice versa. These differences are only tendencies, however, and are not significant, due partly to the relatively small number of animals.

As so the copper level, the results did not change when the site of origin was taken into consideration. The highest copper contents — above 250 ppm on average — were found in the livers of cows from a Danube flood area where the soil is of grassland character (Table 5).

In the kidneys 16—18 ppm copper was found on average; this is a normal value (Table 6). The results show that copper deficiency is not likely to occur on the areas examined.

To sum up, it can be said that the 5 ppm cadmium detected by ANKE *et al.* (1977) in the kidneys of 6-year-old cows in the German Democratic Republic can be regarded as normal. This concentration was not reached in the kidneys of cows nearly twice as old which were examined in Hungary. The cadmium contents of the liver, cerebrum and costal bone agreed with the values found on areas not exposed to cadmium.

On the basis of the present investigations it can be established that on the areas studied so far in Hungary the cadmium exposure is low, though, as mentioned above, the

Table 4

Copper contents (in ppm) in organs of cows aged over 9-year-old
(n = 45)

	Liver	Cerebrum	Kidneys	Costal bone
$\bar{x}$	152	13	17	5.6
s	104	3.6	2.0	23

Table 5

Copper contents (in ppm) in livers of cows from different areas
(n = 45)

	1 (n 9)	2 (n 12)	3 (n 15)	4 (n 9)
$\bar{x}$	257	94	86	131
s	58	76	103	68

Table 6

Copper contents (in ppm) in kidneys of cows from different areas
(n = 45)

	1 (n 9)	2 (n 12)	3 (n 15)	4 (n 9)
$\bar{x}$	18	17	17	16
s	2.0	2.8	1.3	1.8

values obtained do not refer to industrial regions. It must be assumed that in the vicinity of industrial works the cadmium exposure is higher. GERGELY—LINDNER-SZOTYORI (1977) demonstrated larger amounts of cadmium in both mother's milk and cow's milk in the neighbourhood of industrial centres (0.11 and 0.04 mg/l, respectively) than in other places (0.05 and 0.024 mg/l, respectively).

The results are therefore only of an informative nature; the investigations will be continued and extended to include other animal species (sheep, horses).

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Prepared at the Animal Feeding Research Institute of the Research Centre for Animal Husbandry and Feeding, Herceghalom

Á. REGIUS-MŐCSÉNYI, S. SZENTMIHÁLYI

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STUDY ON THE DROUGHT TOLERANCE OF SORGHUM HALEPENSE

One of the main problems in the efficient control of perennial weed plants is how to kill their belowground organs. The success of control carried out with various mechanical instruments (plough, skimmer, disk, cultivator, etc.) depends partly on what the weather is like immediately after the operation. When soil cultivation is followed by a long dry period a high percentage of the rhizomes will be destroyed. In the case of rainy weather, on the other hand, the area becomes overgrown with weeds to a still greater extent because of intensive shooting. One of the aims of soil cultivation is thus to cut up the rhizomes as much as possible and to bring them as close as possible to the soil surface in order to dry and destroy them (Hunyadi 1978).

Soil cultivation carried out in dry weather in middle or late summer is also considered one of the most efficient methods of mechanical control in the relevant literature (Mc Whorter—Hartwig 1965, Kiselev 1971, McWhorter 1972, 1975, Little 1972).

With a view to increasing the efficiency of weed control it is thus worth examining how rhizomes respond to desiccation.

The rhizomes examined were obtained from the S. halepense stock of the Baja Agricultural Combinate, Mátéháza. The freshly dug-up rhizomes were washed and the squamae covering the roots and axillary buds were removed. The rhizomes were cut into pieces each containing 7 segments.

As the first step of the experiment rhizomes with an identical number (7) of segments were withered for various periods (12, 24, 48 hours) under artificially constant conditions. These were then used to establish after how many hours of withering the rhizomes were still able to reach 90% resaturation, the limit value for critical water saturation deficit. Later rhizomes with 7 segments were artificially withered, 50 for 6 hours and 50 for 12 hours. The average length of the rhizomes was 7.94 cm. Weighing was carried out using a torsion balance with 1 mg gradations. An exsiccator with filter paper and a 1 cm layer of water at the bottom was used as a wet chamber. The water content data were used to determine the degree of saturation and resaturation.

Dry matter weights were determined after drying at 105 °C for 12 hours. The extent of critical water saturation was established by the method developed by Stocker (1929) and Magyar (1930) on the basis of the following calculations:

$$\text{Initial deficit } (\%) = \frac{M_1 - K}{M_1 - T} \times 100$$

$$\text{Resaturation deficit } (\%) = \frac{M_2 - T}{M_1 - T} \times 100$$

where M_1 = weight after the 12 hour saturation period
K = weight after withering
M_2 = saturation weight after withering
T = dry weight

The critical saturation deficit (syn.: sublethal saturation deficit, marginal value) is the water level of tissues after withering at which the rhizome is more or less able to regain its original water content. If the tissues of the examined organs lose more water than the value of the critical saturation deficit, the water uptake of the tissues stops and the organs die. The critical saturation deficit is a highly important ecological parameter suitable for determining the drought tolerance of plants (Hunyadi 1978).

The water loss of rhizomes. The 7-segment rhizomes lost 12%, 18.5%, 34% and 42% of their original weight after 6, 12, 24 and 48 hours, respectively, of artificial withering. The

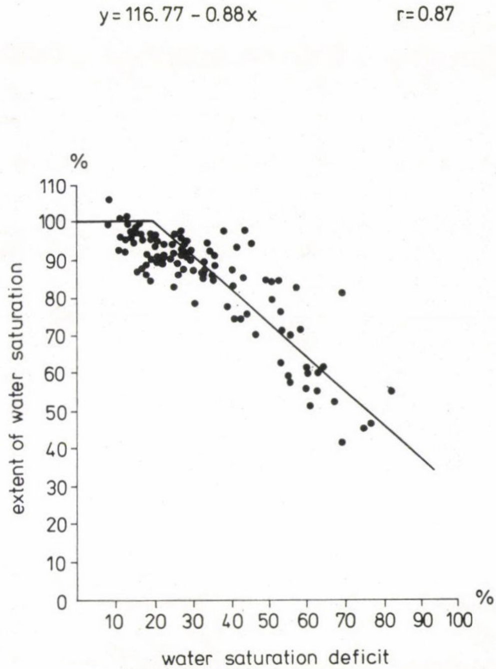

Fig. 1. Trend of critical saturation deficit in rhizomes of *Sorghum halepense* in the period 20–28th April 1978. (1) Extent of resaturation, (2) Water saturation deficit

water loss of 6, 7, 8, 9 and 10 cm 7-segment rhizomes withered for 6 hours decreased in inverse ratio to the increase in length. Rhizomes 6 cm long lost 15% water, while rhizomes 7, 8, 9 and 10 cm long lost 12.2, 12.1, 11.3 and 10.6% water, respectively, on average.

When the rhizomes were withered for 12, 24 and 48 hours no correlation between length and water loss was found.

Critical saturation deficit of rhizomes. The data are contained in Fig. 1. The regression equation for the descending branch of the curve is: $y = 116.77 - 0.88x$. At $y = 90$, the saturation value of the rhizomes is 31%. This value is very low; it shows that the rhizomes of S. halepense are highly reactive to water loss and have extremely low tolerance to drought. This is one explanation of the efficiency of soil cultivation carried out in dry weather.

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Prepared at the Agricultural Combinate, Baja

J. Mikulás

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CRUDE NUTRIENT COMPOSITION AND NUTRITIVE VALUE OF SOME IMPORTANT GRASS SPECIES

In Hungary grasslands play a highly important role in the livestock feed supply, at present making up some 27—29% of the forage supply for ruminants. Parallel to the development of beef cattle and sheep farming the importance of grasslands will increase in the future, but its role in the feed supply of dairy cows will not decrease either.

Few data are available in Hungary with regard to the nutritive value of grasses compared to other fodder crops. So it was aimed to study the grass species which are expected to be of importance in the future, too, owing to their drought tolerance, high yields or other favourable characters. Studies on grasses are also justified by the results of grass improvement in Hungary (JANOVSZKY 1974, NAGY 1977).

The present paper gives an account of a three-year series of experiments carried out under non-irrigated conditions in order to determine the crude nutrient composition and nutritive value of common rye-grass, meadow fescue, smooth brome-grass, orchard grass, tall fescue and reed canary grass.

Table 1

Results of soil analysis

Number	Layer, cm	Arany's viscosity number (C_A)	hy	pH		Humus, %	P_2O_5	K_2O	$CaCO_3$
				H_2O	KCl		mg/100 g soil		
1.	0—30	46	2.27	7.9	7.6	3.93	9.0	19.5	6.4
2.	0—30	42	2.02	8.2	7.8	3.64	7.5	14.0	23.2
3.	0—30	45	2.28	7.9	7.7	4.61	12.3	17.5	7.7
4.	0—30	40	1.92	8.1	7.7	2.83	6.5	12.5	20.3
	30—70	36	1.52	8.2	7.8	1.92	—	—	30.4
	70—130	36	1.42	8.1	7.7	1.52	—	—	16.3
	130—200	35	1.18	8.0	7.7	0.88	—	—	13.7

Note: The soil analyses were performed by the Pest-Nógrád County State Farm Exension Service.

Table 2

Annual amount and monthly distribution of precipitation at Herceghalom

	1975	1976	1977
	mm		
January	15.7	52.5	112.9
February	5.3	5.9	73.3
March	42.3	17.1	49.8
April	38.1	48.9	40.1
May	55.1	57.3	46.3
June	76.6	51.8	18.1
July	107.3	51.0	47.1
August	152.2	51.2	48.4
September	35.5	130.9	27.7
October	57.6	68.1	10.1
November	15.2	40.2	51.8
December	31.4	94.0	23.6
Annual total	632.3	668.9	549.2

Hungarian feeding tables do not contain detailed data on the chemical composition and nutritive value of grass species. Particularly few Hungarian analytical data are available on the digestibility of the different grass species, so the digestible protein contents and starch equivalents are usually calculated on the basis of foreign data. Data on the sugar contents of grass species, important from the point of view of storage after fermentation, are also deficient.

The crude nutrient composition and nutritive value of the hay of individual species are reported by Gruber (1960) on the bais of analyses by Kurelec. The nutrient contents of some species at the flowering stage are published by Herold (1977). Kurelec—Scholtz (1953) analysed the nutrient content in samples taken every month throughout the growth season on several native grasslands used for grazing.

Régius-Mőcsényi–Farries (1973) studied the crude nutrient content and digestibility of the first growth of Italian rye-grass in the course of plant development. Similar studies were carried out by Farries (1966) in a pasture of natural grassland character. The digestibility of the nutrients tended to decrease parallel to maturation. In Farries' investigations the utilization of crude protein and nitrogen-free extract decreased to a greater extent as the crude protein content decreased than did the utilization of crude fat and crude fibre.

Ecker (1977) examined the crude protein and crude fibre content in the first growths of various grass species by analysing samples taken weekly. In reed canary grass more crude protein and less crude fibre were found than in other species. When discussing the properties of grass varieties improved at Szarvas Janovszky (1974) gives the following crude protein values for the different varieties: 18.0—24.0% for smooth brome-grass "G", 15.2—19.6% for meadow fescue "G", 15.0—20.4% for orchard grass "GT" and 13.6—17.0% for common rye-grass "G" 658.

Table 3

Common rye-grass (Lolium perenne)

Sample No.	Maturation stage	Height, cm		Dry matter, g	Crude protein	Crude fat	Crude fibre	N-free extract	Ash	Digestible protein	Starch equiv.
					g/1000 g dry matter						
	First growth										
6	leafy	15–20	$\bar{x}$	198	176	49	201	476	98	136	643
			s	7.2	13.4	4.5	15.9	20.9	6.6	10.2	8.6
			cv%	3.6	7.6	9.1	7.9	4.4	6.7	7.5	1.3
	Digestion coefficients:				77	60	76	76			
7	after appearance of panicles, at the beginning of flowering	25–35	$\bar{x}$	244	139	41	258	489	73	89	514
			s	5.1	13.4	3.6	27.4	2.6	10.9	8.3	15.0
			cv%	2.0	9.6	8.8	10.6	5.4	14.8	9.3	2.9
	Digestion coefficients:				62	57	59	65			
	Summer after-growth										
7	leafy (with a few seed stalks)	10–20	$\bar{x}$	345	107	40	232	545	76	77	523
			s	54.4	9.6	6.2	14.8	23.9	11.3	6.8	13.5
			cv%	15.8	8.9	15.4	6.4	4.4	14.9	8.8	2.6
	Digestion coefficients:				72	59	58	66			
	Autumn after-growth										
14	leafy	10–25	$\bar{x}$	276	170	45	232	460	93	125	557
			s	78.0	24.6	9.5	33.4	24.0	13.7	18.2	12.9
			cv%	28.2	14.4	20.8	14.3	5.2	14.7	14.5	2.3
	Digestion coefficients:				73	50	70	69			

Cizek (1974) observed an increase in digestibility as a response to nitrogen fertilization in experiments carried out with reed canary grass. Behaeghe—Carlier (1973) did not find this effect in common rye-grass, orchard grass or meadow fescue. When studying the effect of nitrogen fertilization Burzlaff—Daigger (1974) discovered a close positive correlation between the digestibility and crude protein content of grasses. The increase in digestibility was in positive correlation with the yield as well.

The utilization of nutrients is considerably influenced by their quality and mutual proportions. Optimum nutrient utilization occurs in the case of a relatively high crude protein content (Baintner 1967).

The general opinion expressed in the literature is that the utilization of the nutrients in grasses greatly depends on the intensity and conditions of cultivation. Detailed information on the digestibility and nutritive value of the different species is given by DEMARQUILLY (1970), WÖHLBIER—KIRSCH (1961), NEHRING *et al.* (1970), BECKER—NEHRING (1969). The grasses studied by these authors had substantially higher water contents, especially in summer and autumn, due to the different conditions in Western Europe. Few data are available on the autumn growths of the grass species. The data for smooth brome-grass and tall fescue are deficient.

Little attention has so far been paid to the sugar content of grass species and how it varies. The sugar content is influenced by several factors including temperature, precipitation, soil quality, fertilization, stage of maturity, age of the leaves or stalks examined, etc. (WERMKE 1976). According to some authors the sugar content in the first growth increases until the appearance of the panicles and then decreases (DIETRICHS *et al.* 1976, WERMKE 1976).

Table 4

Meadow fescue (Festuca pratensis)

Sample No.	Maturation stage	Height, cm		Dry matter, g	Crude protein	Crude fat	Crude fibre	N-free extract	Ash	Digestible protein	Starch equiv.
					g/1000 g dry matter						
					First growth						
9	leafy	20—25	$\bar{x}$	200	196	46	225	427	106	145	612
			s	14.5	25.5	3.8	11.4	29.9	6.5	17.8	10.5
			cv%	7.2	13.0	8.4	5.1	7.0	6.1	12.3	1.7
	Digestion coefficients:				74	55	79	73			
1	after the appearance of panicles	50—70	$\bar{x}$	256	144	39	284	446	87	104	511
			s	39.6	17.2	5.1	20.1	26.1	12.7	12.7	7.7
			cv%	15.4	12.0	12.9	7.1	5.9	14.5	12.2	1.5
	Digestion coefficients:				72	48	66	64			
					Summer after-growth						
14	leafy	10—25		339	124	45	237	511	83	81	526
			s	62.4	18.4	2.9	18.0	22.3	10.8	11.4	9.9
			cv%	18.4	14.8	6.5	7.6	4.4	13.0	14.1	1.9
	Digestion coefficients:				65	51	69	65			
					Autumn after-growth						
20	leafy	15—30	$\bar{x}$	274	167	41	239	457	96	114	538
			s	46.8	20.9	5.1	31.3	20.5	13.4	13.9	12.9
			cv%	17.1	12.6	12.4	13.1	4.5	14.0	12.3	2.4
	Digestion coefficients:				68	47	73	66			

Table 5

Orchard grass (Dactylis glomerata)

Sample No.	Maturation stage	Height, cm		Dry matter, g	Crude protein	Crude fat	Crude fibre	N-free extract	Ash	Digestible protein	Starch equiv.
					g/1000 g dry matter						
	First growth										
9	Shooting	25—40	$\bar{x}$	193	173	50	238	442	97	132	602
			s	7.4	11.3	4.4	14.8	17.9	9.9	8.7	8.0
			cv%	3.8	6.5	8.7	6.2	4.1	10.3	6.6	1.3
	Digestion coefficients:				76	55	75	71			
11	after the appearance of panicles, at the beginning of flowering	60—80	$\bar{x}$	250	147	45	283	445	80	104	466
			s	30.1	17.4	5.2	20.0	20.0	12.3	11.9	9.1
			cv%	12.0	11.8	11.7	7.0	4.5	15.2	11.4	1.9
	Digestion coefficients:				71	50	58	58			
	Summer after-growth										
15	after the appearance of panicles	20—50	$\bar{x}$	376	115	50	280	463	92	75	455
			s	62.2	15.7	6.9	29.6	30.0	11.1	10.0	15.4
			cv%	16.6	13.7	13.7	10.6	6.5	11.9	13.4	3.4
	Digestion coefficients:				66	47	68	58			
	Autumn after-growth										
25	leafy	20—40	$\bar{x}$	269	163	51	236	458	92	109	495
			s	66.9	23.9	6.8	25.1	45.6	17.0	15.7	11.2
			cv%	24.9	14.6	13.3	10.7	10.0	18.4	14.3	2.3
	Digestion coefficients:				67	43	66	60			

To study the feeding value of grass species a grass trial ground was established at Herceghalom in the spring of 1974. In the first stage the feeding value of smooth brome-grass, orchard grass, reed canary grass, tall fescue, common rye-grass and meadow fescue was studied.

In order to study the six species, 26 trial plots were formed, in which varieties of these species were sown in pure stands. The plots were either 440 or 15 m² in size. The seed was made available by the two Hungarian grass improving stations (Keszthely and Szarvas).

The experimental area slopes slightly in a southerly direction; the soil is a lime-coated chernozem developed on loess. The phosphorus and potassium contents of the upper layer were at a medium level on planting. Detailed soil analytical data are presented in Table 1. Prior to planting the area was fertilized with 105 kg P_2O_5 and 300 kg K_2O active agent per hectare. The amount of active agent applied subsequently was 180 kg/ha N, 60 kg/ha P_2O_5 and 160 kg/ha K_2O a year. The nitrogen was distributed on three occasions: in autumn (30 kg/ha), in early spring (70 kg/ha) and after the first growth was cut (70 kg/ha), while the phosphorus and potassium fertilizers were applied on a single occasion in autumn.

The investigations were carried out in 1975, 1976 and 1977. Information on the amount and monthly distribution of precipitation in the successive years is given in Table 2. The grass samples were taken when both the quantity and quality of the crop were suitable for cutting or grazing, with the effects of season and weather taken into consideration. Aging crops were not analysed. Samples were taken on 3—6 occasions from each plot. In 1976 samples could only be taken from some species in spring and autumn owing to the drought (common rye-grass, meadow fescue).

Table 6

Tall fescue (Festuca arundinacea)

Sample No.	Maturation stage	Height, cm		Dry matter, g	Crude protein	Crude fat	Crude fibre	N-free extract	Ash	Digestible protein	Starch equiv.
					g/1000 g dry matter						
					First growth						
9	leafy	35—40	$\bar{x}$	204	177	40	241	442	100	131	546
			s	13.7	21.0	3.2	11.9	19.7	11.8	15.6	10.8
			cv%	6.7	11.9	8.0	4.9	4.4	11.9	11.9	2.0
	Digestion coefficients:				74	52	68	65			
10	after the appearance of panicles	50—70	$\bar{x}$	251	148	36	268	467	81	96	423
			s	15.8	14.4	4.5	14.9	17.8	6.4	9.5	8.4
			cv%	6.3	9.7	12.6	5.6	3.8	7.9	9.9	2.0
	Digestion coefficients:				65	49	58	50			
					Summer after-growth						
17	leafy	25—40	$\bar{x}$	321	138	40	242	494	86	92	474
			s	40.9	25.7	3.6	14.6	17.2	8.0	16.7	9.9
			cv%	12.8	18.6	8.8	6.0	3.5	9 3	18.0	2.1
	Digestion coefficients:				67	41	61	59			
					Autumn after-growth						
18	leafy	25—35	$\bar{x}$	282	162	41	228	480	89	117	503
			s	83.2	26.7	5.6	24.5	35.6	14.6	17.6	9.1
			cv%	29.5	16.5	13.6	10.7	7.4	16 3	15.0	1.8
	Digestion coefficients:				72	38	65	61			

Table 7

Smooth brome-grass (Bromus inermis)

Sample No.	Maturation stage	Height, cm		Dry matter g	Crude protein	Crude fat	Crude fibre	N-free extract	Ash	Digestible protein	Starch equiv.
					g/1000 g dry matter						
					First growth						
8	leafy	30–40	$\bar{x}$	180	202	45	242	413	98	164	617
			s	18.0	20.0	6.4	14.3	20.9	16.2	16.4	13.0
			cv%	10.0	9.9	14.2	5.9	5.1	16.4	10.0	2.1
	Digestion coefficients:				81	54	78	73			
7	after the appearance of panicles	50–70	$\bar{x}$	246	153	36	277	458	76	104	441
			s	22.3	17.4	6.2	15.3	14.3	9.1	11.7	10.6
			cv%	9.0	11.3	17.4	5.5	3.1	12.0	11.2	2.4
	Digestion coefficients:				68	34	58	55			
					Summer after-growth						
13	leafy	15–35	$\bar{x}$	340	170	44	262	439	85	118	458
			s	56.0	37.1	8.0	34.6	27.1	10.3	26.3	15.9
			cv%	16.4	21.9	18.3	13.2	6.2	12.2	22.3	3.5
	Digestion coefficients:				71	34	65	56			
					Autumn after-growth						
12	leafy	15–35	$\bar{x}$	264	224	46	196	435	99	161	524
			s	83.1	23.6	4.4	20.5	22.1	17.8	17.9	14.9
			cv%	31.5	10.6	9.5	10.4	5.1	18.0	11.0	2.8
	Digestion coefficients:				71	36	70	60			

Samples for both the laboratory analyses and the digestibility experiments were cut with a hand scythe, leaving 2–4 cm stubble. The samples used in the laboratory analyses were processed immediately while the larger number of samples cut for the feeding experiments were chopped up and then stored at –22 °C. To determine the crude nutrient content in the six species a total of 274 Weendei analyses were carried out according to standard MSZ 6830–66; the digestibility was determined in 47 digestibility trials carried out with wethers according to the method elaborated at the Research Institute for Animal Husbandry. The starch equivalent was calculated according to standard MSZ 6830–66, on the basis of the digestibility determined in the current experiments.

The sugar content was determined from 208 dried and ground grass samples. The chemical method applied was Bertrand's sugar test, which included not only glucose, fructose and fructosan, but also other sugars which were present in smaller quantities.

Table 8

Reed canary grass (Baldingera arundinacea)

Sample No.	Maturation stage	Height, cm		Dry matter, g	Crude protein	Crude fat	Crude fibre	N-free extract	Ash	Digestible protein	Starch equiv.
					g/1000 g dry matter						
					First growth						
5	leafy, shooting	30–40	$\bar{x}$	190	188	43	247	431	91	155	621
			s	11.5	24.8	9.3	23.6	24.9	9.7	18.4	4.7
			cv%	6.0	13.2	21.5	9.5	5.8	10.7	11.9	0.8
	Digestion coefficients:				83	51	78	73			
5	after the appearance of panicles	70–90	$\bar{x}$	247	149	41	270	471	69	104	454
			s	32.9	14.0	5.7	15.5	27.7	5.3	9.8	7.4
			cv%	13.3	9.4	13.3	5.7	5.9	7.6	9.4	1.6
	Digestion coefficients:				70	32	56	58			
					Summer after-growth						
10	leafy, shooting	25–50	$\bar{x}$	289	179	49	239	448	85	127	497
			s	35.9	19.8	6.7	20.8	24.3	9.2	14.1	20.5
			cv%	12.4	11.0	13.7	8.7	5.4	10.8	11.1	4.1
	Digestion coefficients:				71	39	67	60			
					Autumn after-growth						
11	leafy	20–40	$\bar{x}$	270	188	47	222	451	92	137	498
			s	61.9	24.8	6.3	28.5	34.5	11.8	18.0	9.1
			cv%	22.9	13.0	13.5	12.8	7.6	12.7	13.2	1.8
	Digestion coefficients:				73	47	65	57			

The analytical results are presented in tabular form. Tables 3—8 contain the means of the analytical results, the digestion coefficients, the digestible crude protein contents and the starch equivalents of the grass species. The results were analysed in four parts on the basis of the growth season. For the first growth two data series reflecting the conditions at the beginning and end of May are presented, while the after-growths are grouped by season as summer and autumn growths. The standard deviations and variation coefficients of the data are also presented. Data in the table indicating the height of the grass are estimates and show the height of the leafy mass and not of the inflorescence. The data are expressed in 1000 g dry matter to make comparison easier.

During the trial period both rainy and dry summers and autumns occurred, as shown by the wide variation in the dry matter values of the after-growths.

As mentioned above, the results of digestibility trials were used to determine the starch equivalents and digestible crude protein contents of the samples examined. The mean values of the six grass species were compared. The results of tests of significance are summarized in Tables 10—11.

Table 9

Total sugar content of grass species, g/1000 g dry matter

	Common rye grass	Meadow fescue	Orchard grass	Tall fescue	Smooth brome grass	Reed canary grass
First growth, young						
n	7	10	11	9	5	5
$\bar{x}$	115.2	64.8	83.4	59.2	49.8	58.7
s	38.6	17.9	21.8	9.3	15.2	16.8
cv%	33.5	27.7	26.1	15.6	30.5	28.6
From the appearance of panicles to the beginning of flowering						
n	6	7	9	8	4	4
$\bar{x}$	126.2	69.8	71.3	72.5	46.8	64.1
s	27.1	26.1	7.8	12.3	4.6	20.5
cv%	21.5	31.4	10.9	16.9	9.8	32.0
After-growth, summer						
n	5	10	14	14	9	9
$\bar{x}$	108.5	80.3	74.0	81.5	64.9	66.7
s	23.3	11.6	17.9	9.7	13.7	9.6
cv%	21.5	14.4	24.2	11.9	21.0	14.4
After-growth, autumn						
n	8	11	16	14	8	5
$\bar{x}$	113.1	83.0	99.8	107.0	76.6	80.5
s	32.7	20.4	26.9	33.0	27.7	22.1
cv%	28.9	24.6	26.9	30.8	36.1	27.4

In the experiments the starch equivalent per 1000 g dry matter was significantly higher for common rye-grass and meadow fescue, and lower for orchard grass and tall fescue than for the other four species. The higher energy values of common rye-grass and meadow fescue and the lower values of orchard grass and tall fescue correspond to the results published by Demarquilly (1970).

The largest amount of digestible crude protein was found for smooth brome-grass and reed canary grass. The crude protein contents of these grasses, as in the data published by Janovszky (1974) and Ecker (1977), were high compared to those of the other species, and the digestibility was also favourable.

Higher values were obtained for the energy and digestible protein contents of the grass species in the period preceding shooting in spring; foreign authors, namely Demarquilly (1970), Wöhlbier—Kirsch (1961) and Nehring *et al.* (1970), have arrived at similar conclusions.

As regards the digestible protein content and energy level of the after-growth in summer and autumn the literary data are contradictory. This can probably be explained by the fact that not only the development, but also the nutritive value of the after-growth is greatly influenced by the weather conditions. The dry matter content in both the summer (24.7—48.8%) and autumn (15.1—51.0%) after-growths ranged between very wide limits in spite of the fact that samples were not taken from parched, unusable grasses. These extreme changes indicate that it is very important to take the dry matter content of the grass into consideration from the point of view of feeding. Due to the higher dry matter content the nutrient content per kg grass may be as much as one-third higher in summer and autumn than at the beginning of May. This is clearly seen in Table 11, where the most important analytical results for the six grass species are summarized.

Table 10

Comparison of grass species for starch equivalent

Species		$\bar{x}$ q	Smooth brome grass	Tall fescue	Meadow fescue	Reed canary grass	Orchard grass
Smooth brome grass	a	617					
	b	441					
	c	458					
	d	524					
Tall fescue	a	546	×××				
	b	423	××				
	c	474	NS				
	d	503	×××				
Meadow fescue	a	612	NS	×××			
	b	511	×××	×××			
	c	526	×××	×××			
	d	538	××	×××			
Reed canary grass	a	621		×××	NS		
	b	454	NS	×××	×××		
	c	497		××	NS		
	d	498		NS	×××		
Orchard grass	a	602		×××	NS	×××	
	b	466	NS	×××	×××	NS	
	c	455		×××	×××	××	
	d	495		NS	×××	NS	
Common rye grass	a	643	××	×××	×××	×××	×××
	b	514	×××	×××	NS	NS	×××
	c	523	×××	×××	NS	NS	×××
	d	557	×××	×××	×	×××	×××

a = first growth, young;
b = first growth, from the appearance of panicles to the beginning of flowering;
c = after-growth in summer;
d = after-growth in autumn;
NS = non-significant;
× = $P\% < 5$:
×× = $P\% < 1$;
××× = $P\% < 0.1$.

The results of sugar analyses are presented in Table 7. The sugar level of summer after-growths was significantly higher ($P < 1\%$) compared to the first growths, while the sugar contents of the autumn after-growths, except in common rye-grass, substantially exceeded the total sugar contents of the previous growths ($P < 0.1\%$).

Table 11

Comparison of grass species for digestible crude protein

Species		$\bar{x}$ g	Smooth brome grass	Tall fescue	Meadow fescue	Reed canary grass	Orchard grass
Smooth brome grass	a	164					
	b	104					
	c	118					
	d	161					
Tall fescue	a	131	××				
	b	96	NS				
	c	92	××				
	d	117	×××				
Meadow fescue	a	145	NS				
	b	104	NS	NS			
	c	81	×××				
	d	114	×××				
Reed canary grass	a	155	NS	×	NS		
	b	104	NS	NS	NS		
	c	127	NS	×××	×××		
	d	137	××	××	×××		
Orchard grass	a	132	×××			×	
	b	104	NS	NS	NS	NS	
	c	75	×××			×××	
	d	109	×××			×××	
Common rye grass	a	136	×××				
	b	89	×	NS	NS	NS	NS
	c	77	××				
	d	125	×××				

a = first growth, young;
b = first growth, from the appearance of panicles to the beginning of flowering;
c = after-growth in summer;
d = after-growth in autumn;
NS = non-significant;
× = $P\% < 5$;
×× = $P\% < 1$;
××× = $P\% < 0.1$.

Table 12

Comparison of grass species for sugar content

Species	$\bar{x}$ g	Common rye grass	Orchard grass	Tall fescue	Meadow fescue	Reed canary grass
Common rye grass	115.8					
Orchard grass	82.1	×××				
Tall fescue	80.1	×××	NS			
Meadow fescue	74.5	×××	NS	NS		
Reed canary grass	67.5	×××	××	××	NS	
Smooth brome grass	59.5	×××	×××	××	××	NS

NS = non-significant
× = P < 5.0%
×× = P < 1.0%
××× = P < 0.1%

Common rye-grass contained significantly more sugar (P < 0.1%) and smooth brome-grass significantly less (P < 1.0%) than the other species (Tables 3, 12).

The results of crude protein and total sugar analyses were used to calculate the sugar/protein ratio of the grass species, which is regarded as one of the most important indices for ensilation. For first growths mature for cutting, values of between 0.4 and 0.5 were obtained for meadow fescue, reed canary grass, orchard grass and tall fescue, while in the case of common rye-grass and smooth brome-grass the sugar/protein ratio calculated from mean values was 0.91 and 0.30, respectively.

The investigations were considerably hindered by the droughty weather in the summers of 1976 and 1977. The summer of 1976 was particularly unfavourable; on the other hand, this provided an opportunity to study the species for drought resistance, which is of primary importance from the point of view of feeding and grazing under dry farming conditions.

In the plots of the examined species the proportion of leaves and parts of leaves which were green on 28th July 1976 were as follows (values estimated by scoring 1 m^2):

	Percentage of green leaves			
	Plot A	Plot B	Plot C	Plot D
Common rye-grass	20	25	20	
Meadow fescue	45	35	25	30
Orchard grass	50	70	60	75
Tall fescue	80	90	80	85
Smooth brome-grass	100	100	90	
Reed canary grass	100	100		

It can be established that there are considerable differences between the grass species and between the successive growths within the individual species in respect of starch equivalent, digestible protein content and total sugar content. However, favourable characters do

Table 13

Nutrient content in grass species

Species	Dry matter, g	Crude protein	Crude fibre	Digestible protein	Starch equiv.	Digestible protein	Starch equiv.
		with original water content, g				g/1000 g dry matter	
Young				First growth			
Common rye-grass	198	35	40	27	127	136	643
Meadow fescue	200	39	45	29	122	145	612
Orchard grass	193	33	46	25	116	132	602
Tall fescue	204	36	49	27	111	131	546
Smooth brome grass	180	36	44	30	111	164	617
Reed canary grass	190	36	47	29	118	155	621
From the appearance of panicles to the beginning of flowering							
Common rye grass	244	34	63	22	125	89	514
Meadow fescue	256	37	73	27	131	104	511
Orchard grass	250	37	71	26	117	100	466
Tall fescue	251	37	67	24	106	96	423
Smooth brome grass	246	38	68	26	108	104	441
Reed canary grass	247	37	67	26	112	104	454
				Summer after-growth			
Common rye grass	345	37	80	27	180	77	523
Meadow fescue	339	42	80	27	178	81	526
Orchard grass	375	43	105	28	171	75	455
Tall fescue	321	44	78	30	152	92	474
Smooth brome grass	340	58	89	40	156	118	458
Reed canary grass	289	52	69	37	144	127	497
				Autumn after-growth			
Common rye grass	276	47	64	35	154	125	557
Meadow fescue	274	46	65	31	147	114	538
Orchard grass	269	44	63	29	133	109	495
Tall fescue	282	46	64	33	142	117	503
Smooth brome grass	264	59	52	43	138	161	524
Reed canary grass	270	51	60	37	134	137	498

not usually appear together in a single species, even for these few aspects. Considering the fact that in addition to these characters, not only drought resistance but also many other factors (yield potential, nitrogen tolerance, tastiness, etc.) influence the value of a grass species it is obvious that in each case species suited to the purpose of production and the local conditions should be chosen. As regards nutritive value all the six species are capable of giving good quality crops with adequate digestibility, but the differences between species and growths in nutritive value, dry matter and total sugar content should be taken into account from the point of view of feeding, grazing and ensilation.

*

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J. Várhegyi, M. Kemenes, I. Várhegyi

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A PROMISING TALL MUTANT IN THE INDICA RICE VARIETY LATISAIL

The increase in grain yield of indica rice (*Oryza sativa* L.) is accompanied by a steady shortening of the straw length. The short statured varieties, in contrast to the tall ones, are better suited to higher fertilizer levels, while remaining resistant to lodging during the flowering and grain-filling periods. Hence, the necessity of inducing mutants with short stature associated with other desirable attributes was recognized for the genetic improvement of traditionally tall-growing varieties. There is evidence that the induction of desirable plant types responsive to high fertilizer levels is possible in barley and rice (GUSTAFSSON 1954, HU *et al.* 1960, LI *et al.* 1962). Plant type is considered to be an important criterion with regard to varietal response to nitrogen (BEACHELL—JENNING 1965, TANAKA *et al.* 1966). Modification of the plant type through mutation for the improvement of rice varieties in regard to fertilizer response may prove to have great potential.

The present study, however, deals with the induction of a tall improved mutant (LSM-6/1) from a local tall indica variety (Latisail) and its evaluation for yield and yield components, internode length pattern, yielding ability and inheritance pattern of the induced characters.

Mature and dehusked seeds of a well adapted regional variety of the indica rice (*Oryza sativa* L.) cultivar Latisail, were soaked in distilled water for 30 minutes and then treated with a freshly prepared 1% non-buffered aqueous solution of ethyl methanesulphonate (EMS) for 0 (control), 2, 4, 5, 6, 8, 10 and 12 hours at room temperature (29 ± 1 °C). Dry and dehusked seeds were subjected to a 20 kR dose of X-rays. Another set of irradiated seeds were again soaked in 1% EMS for 4 hours. After single and combined treatments with EMS the seeds were thoroughly rinsed for 2 hours in running tap water. A set of control seeds were kept in petri dishes on filter paper moistened with distilled water. All sets of treatments including the control consisted of 100 seeds. The treated as well as the control seeds were allowed to germinate in seed pans. After 3 weeks, the seedlings were transplanted into the field with one plant per hill.

At maturity, the seeds of all plants were harvested separately and used to grow plant-to-row progenies in the M_2 generation. After screening for chlorophyll mutations the seedlings were transplanted into the field after 3 weeks with one plant per hill. All M_2 plants were screened for various morphological and grain type mutations from flowering to harvest. On the basis of phenotypic abnormality, five mutants (LSM-19/12, LSM-6/1, LSM-28/2, LSM-18/14 and LSM-45/9), among many others, were isolated for further evaluation. The selected mutants were grown in the M_3 generation for confirmation and homogeneity.

The five mutants were raised together with the control in a randomized block design using four replications in the M_4 generation. The plot size used was 10.8 m^2, containing 8 rows 30 cm apart. Each row was 4.5 m long an contained 15 plants grown 30 cm apart. Observations on yield components and internode length were recorded on 10 randomly chosen plants per plot. Each plot was harvested separately at maturity and the yield was determined as q/ha.

On the basis of its performance in M_4, one induced mutant (LSM-6/1) was selected for a final yield trial in the M_5 generation. One variety Dahar Nagra, which is also a well adapted regional variety, was included as a standard check in the yield trial along with Latisail (control) and the promising mutant (LSM-6/1). These three entries were tested in a randomized block design, using three replications. The plot size was 10.8 m^2 and the spacing was 23×23 cm. Four levels of nitrogen (0, 50, 100 and 150 kg N/ha) and one level each of potassium and phosphorus (75 kg/ha K_2O and 150 kg/ha P_2O_5) were used. Harvesting was done separately for all the 36 plots in bulk, and the grain yield was determined as q/ha.

The extremely tall promising mutant LSM-6/1 was crossed with Latisail to determine the inheritance pattern of the induced characters. Data were collected on the segregation of tallness in the F_2 and F_3 generations and from the F_2 of backcrosses with Latisail. Data were also collected on joint segregation for tallness and late maturity in the F_2 generation.

Mean values of yield and yield components of the mutant LSM-6/1 (isolated from a 5-hour EMS treatment) along with other induced mutants and the control in the M_4 generation, indicate that the mutant was significantly later maturing than the control (Table 1). Further, the mutant LSM-6/1 was significantly better in respect of height, panicle length, fertile grains per panicle and yield (Fig. 1). But the mutant poroduced a lower number of tillers per plant. The 1000-grain-weight was almost equal to that of the control. The mutant LSM-18/14 was also significantly taller than the control, while the other three mutants (LSM-19/12, LSM-28/2 and LSM-45/9) were significantly shorter. The individual internode lengths of the mutants LSM-6/1 and LSM-18/14 were also longer than the control, while those of the other three mutants were shorter (Table 2). All the mutants produced significantly less tillers,

Table 1

Mean yield components and yield of Latisail (control) and its five induced mutants in the M_4 generation

Control and mutants	Heading duration (days)	Height (cm)	Tillers/plant (No.)	Panicle length (cm)	Fertile grains/panicle (No.)	1000-grain weight (g)	Yield/ha (q)	Increased or decreased yield of mutants compared to control
Control	134.25	110.25	47.75	23.00	101.25	26.70	114.92	−90.21
LSM-19/12	138.25**	74.50**	30.75**	15.50**	20.50**	19.37**	11.25**	−90.21
LSM-6/1	137.75**	160.75**	30.00**	26.15*	147.75**	26.02	126.82*	+10.35
LSM-28/2	140.50**	54.87**	186.75**	7.72**	15.00**	20.17**	18.07**	−84.27
LSM-18/14	135.75**	126.87**	27.25**	17.37**	52.50**	24.10**	41.27**	−64.08
LSM-45/9	136.00**	58.62**	15.75**	18.22**	92.50**	18.05**	43.52**	−62.13

Significant at the 5% (*) and 1% (**) levels, respectively.

Table 2

Mean individual internode length of the control (Latisail) and the induced mutants in the M_4 generation

Control and mutants	Mean internode length (cm)				
	I	II	III	IV	V
Control	31.12	18.70	12.42	11.22	7.47
LSM-19/12	19.72** (−36.63)	15.30** (−18.18)	10.65 (−14.25)	6.75 (−39.84)	5.10 (−31.73)
LSM-6/1	35.70** (+14.72)	21.95* (+17.38)	21.62** (+74.07)	18.37* (+63.73)	12.25* (+63.99)
LSM-28/2	13.85** (−55.49)	7.15** (−61.76)	4.67** (−62.40)	3.82* (−65.95)	1.92* (−74.30)
LSM-18/14	32.70 (+5.08)	23.05** (+23.26)	15.67 (+26.17)	15.12 (+34.76)	9.37 (+25.44)
LSM-45/9	21.27** (−31.67)	10.12** (−45.88)	9.77 (−21.34)	5.02 (−55.26)	3.95 (−47.12)

Internode I is the uppermost.
Figures in parentheses indicate % increase or decrease over the control.
Significant at the 5% (*) and 1% (**) levels, respectively.

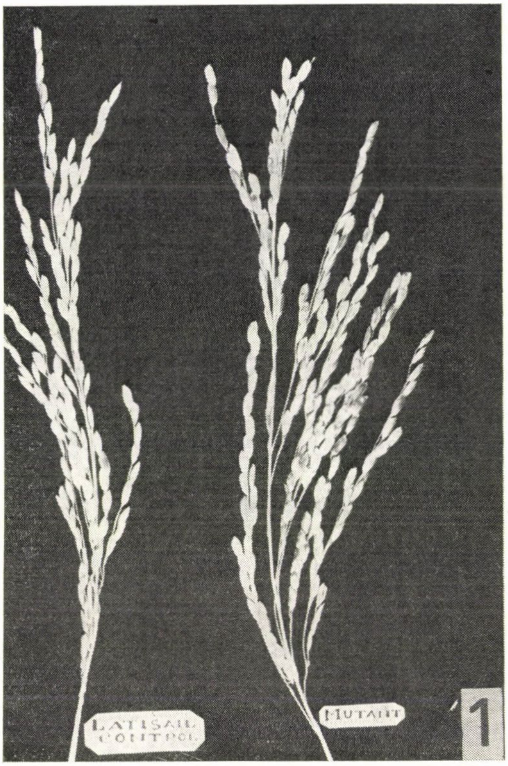

Fig. 1. Normal panicle (left); mutant panicle (right), showing larger number of grains in the panicle

except for LSM-28/2, which is a dwarf bushy type producing an exceedingly large number of tillers, similar to those observed earlier (GHOSH HAJRA *et al.* 1978, MALLICK 1978). This bushy dwarf plant type with erect, dark green leaves has been considered as an important criterion with regard to the satisfactory response to fertilizer use and higher sowing density (BEACHELL—JENNINGS 1965, BOROJEVIĆ—BOROJEVIĆ 1972, TANAKA *et al.* 1966). Further, plants with small, thick, erect, dark green leaves can make efficient use of solar radiation and could be used to evaluate the physiological aspect of crop productivity (MALLICK *et al.* 1978). Various reports (BOROJEVIĆ—BOROJEVIĆ 1972, FUTSUHARA *et al.* 1967, KHAN 1973, REDDY—REDDY 1971) indicate that the yield was higher in short-statured mutants of cereals as compared to the tall parental varieties. But in complete contrast to the above, the induced dwarf mutants (LSM-19/12, LSM-28/2 and LSM-45/9) were very inferior in yield to both the control and the mutant LSM-6/1, due to a significant reduction in panicle length, fertile grains per panicle and 1000-grain-weight.

The mean grain yields of the promising induced mutant (LSM-6/1) and of two regional varieties at four levels of nitrogen, studied in the M_5 generation, are presented in Table 3. It is evident that the grain yield of the mutant increased parallel to increasing nitrogen application from 0 to 150 kg/ha. The yield return at the 150 kg N/ha level as compared to the 100 kg N/ha level was not significant and thus not economic. This response of the mutant to the higher level of nitrogen might be due to the fact that tall plant types of rice do not respond satisfactorily to maximum fertilizer use (BEACHELL—JENNINGS 1965). The significant varietal effects observed (Table 4) indicate that the mutant LSM-6/1 was better yielding than either Latisail or Dahar Nagra (the standard check).

Table 3

Mean yield (q/ha) of standard regional varieties and induced mutants at four levels of nitrogen in the M_5 generation

Varieties and mutant	Nitrogen levels (kg/ha)				
	0	50	100	150	Mean
Latisail (control)	9.96	10.80	12.80	13.63	11.79
Dahar Nagra (check)	9.53	10.30	12.00	12.76	11.14
LSM-6/1	10.43	11.93	13.33	13.90	12.39
Mean	9.97	11.01	12.71	13.43	

Table 4

Analysis of variance for yield based on the data presented in Table 3

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares
Replication	2	0.851	0.425*
Varieties and mutant	2	9.380	4.690**
Nitrogen	3	66.956	22.318**
Varieties and mutant × nitrogen	6	0.847	0.141
Error	22	1.716	0.078

Significant at the 5% (*) and 1% (**) levels, respectively.

Table 5

Inheritance of extreme tallness in the cross of Latisail × LSM-6/1 and probability of a fit to a 1 tall : 2 segregating : 1 extremely tall ratio

Cross	Height class			Ratio tested	Goodness of fit (P)
	Tall (100–120 cm)	Segregating	Extremely tall (150–170 cm)		
Latisail × LSM-6/1					
F_1	8			All tall	
F_2	438		162	3 : 1	0.20–0.30
F_3	328	670	362	1 : 2 : 1	0.30–0.50
BC_1 Latisail	11		9	1 : 1	0.50–0.70
F_2 of BC_1 Latisail		102	98	1 : 1	0.70–0.80

Table 6

Inheritance of extreme tallness and late maturity in the cross of Latisail×LSM-6/1 and probability of a fit to a 9 : 3 : 3 : 1 ratio

Tall, medium maturity	Tall, late maturity	Extremely tall, medium maturity	Extremely tall, late maturity	Goodness of fit (P)
312	116	132	40	0.10–0.20

The inheritance of the extreme tallness of the mutant LSM-6/1 was investigated in crosses with its tall parent. Apparent segregation ratios of 3 tall : 1 extremely tall were observed in the F_2 generation (Table 5). The F_3 generation showed a ratio of 1 tall : 2 segregating : 1 extremely tall which confirmed that the extremely tall stature of LSM-6/1 was controlled by a single recessive gene. In joint segregation of plant height and heading duration, a ratio of 9 tall, medium maturity : 3 tall, late maturity : 2 extremely tall, medium maturity : 1 extremely tall, late maturity was observed (Table 6). The segregation ratio confirmed that the late maturity of the extremely tall mutant was also controlled by a recessive gene and the late maturity and extremely tall stature characters were inherited independently.

In conclusion, the mutant LSM-6/1 seems to be quite promising owing to the longer panicles and the increased number of fertile grains per panicle. It was probably these two characteristics which led to the mutant giving 10.3% higher yield than the parental variety (Latisail) and 11.7% higher than the standard check variety (Dahar Nagra).

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*

Prepared at the Department of Botany, Burdwan University, Burdwan

N. G. Hajra, E. H. Mallick, P. Bairagi

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EFFECT OF SOME HERBICIDES ON THE INFECTIVITY OF TOMATO MOSAIC VIRUS

Few investigators have studied the effect of herbicides on the infectivity of viruses; none of them have used the same techniques or the same herbicides as those applied in this paper.

Folsom (1952) found that the use of herbicides is a practical control measure for potato leaf-roll virus. Bobyr—Zhmurko (1970) found that out of 35 physiologically active substances, 12 inhibit tobacco mosaic virus (TMV) *in vitro*. Horváth—Hunyadi (1973) found that the multiplication of alfalfa mosaic virus and TMV in the intact primary leaves of bean is inhibited by the incorporation of trifluralin herbicide.

The effect of the following herbicides on the infectivity of tomato mosaic virus was studied: 1. Cotoran (fluometuron) 80%; 3-(m-trifluoromethyl-phenyl)-1,1-dimethylurea. 2. Dicuran (chlortoluron) 80%; 3-(3-chloro-4-methyl-phenyl)-1, 1-dimethylurea. 3. Patoran (metobromuron) 50%; 3-(p-bromophenyl)-1-methyl-1-methoxyurea.

The three compounds were kindly supplied by Ciba-Geigy. Various concentrations of herbicides were prepared in distilled water according to their solubility:

10, 50, 90 ppm of Cotoran
10, 50, 70 ppm of Dicuran
10, 90, 200, 330 ppm Patoran.

The virus was extracted from tobacco leaves *(Nicotiana tabacum* var. *angustifolia)* infected with the virus and showing mosaic symptoms. The effect of herbicides on virus infectivity was studied both *in vitro* and *in vivo*. *Datura metel* was chosen as the test plant, as it can be easily cultivated, and a large number of local lesions are developed on a single inoculated leaf within 3—4 days after inoculation with the virus. The number of local lesions produced on the detached *Datura* leaves was taken as an assay for the infectivity of the virus. This number was converted to a percentage of the control.

The inoculation of the leaves was carried out using the index finger after dusting the leaves with 600-mesh carborundum. The leaf was supported in the palm of the left hand, the leaf apex pointing towards the wrist and the petiole downwards between the 2nd and 3rd fingers. The leaves were rubbed firmly but gently over the entire upper surface. They were exposed to a constant number of strokes with the finger and then washed quickly with tap water.

Table 1

Effect of various concentrations of Cotoran on the number of local lesions

Dilution of virus	Different figures for the number of local lesions	Number of local lesions			
		Control	Virus treated with various concentrations of Cotoran for half an hour		
			10 ppm	50 ppm	90 ppm
	Total (for 4 leaves)	232.0	369.0	286.0	398.0
10^{-1}	Mean No./leaf	58.0	92.3	71.5	99.5
	Mean percentage of control	100.0	159.1	123.3	171.6
	Total (for 4 leaves)	56.0	68.0	66.0	68.0
10^{-2}	Mean No./leaf	14.0	17.0	16.5	17.0
	Mean percentage of control	100.0	121.4	117.9	121.4
	Total (for 4 leaves)	37.0	42.0	19.0	33.0
10^{-3}	Mean No./leaf	9.3	10.5	4.8	8.3
	Mean percentage of control	100.0	112.9	51.6	89.2
	Total (for 4 leaves)	13.0	28.0	10.0	2.0
10^{-4}	Mean No./leaf	3.3	7.0	2.5	0.5
	Mean percentage of control	100.0	212.1	75.8	15.2

Effect of herbicides on virus infectivity in vitro

The effect of different concentrations of each herbicide together with a corresponding control at a certain virus dilution was studied in a separate experiment. A Latin square design in which each inoculum occurs once on each plant and once at each leaf position was used. Thus, for testing 4 inocula, 4 plants each with 4 suitable leaves were used, and for testing 5 inocula, 5 plants each with 5 suitable leaves were used. The inocula were distributed in such a manner that each inoculum occurred once on each plant and once at each leaf position.

50–60-day-old *Datura metel* plants with 4 or 5 suitable leaves were chosen. The two cotyledonary leaves and the first and second leaves from the base were discarded. Leaves in the third, fourth, fifth, sixth and seventh positions from the base were used and any more leaves from the apex were discarded. The leaves were detached and arranged in Petri dishes with water-moistened filter paper.

0.1 ml of the expressed sap containing the virus was added to 0.9 ml of 10, 50 and 90 ppm Cotoran, mixed well and allowed to stand for 30 minutes. At the same time a control sample of the virus diluted 10 times in distilled water was prepared. The virus — Cotoran mixtures and the control were then inoculated into detached leaves of 4 *Datura metel* plants, each with 4 suitable leaves.

The same experiment was repeated, but this time the virus — Cotoran mixtures were diluted quickly to 10^{-2} after being incubated for 30 minutes and then inoculated into the leaves of 4 other plants using the previous design. The control sample at this time consisted of the virus diluted in distilled water to 10^{-2}.

produced by tomato mosaic virus in vitro on detached leaves of Datura metel

Number of local lesions							
Control	Virus treated with various concentrations of Cotoran for 6 hours			Control	Virus treated with various concentrations of Cotoran for 24 hours		
	10 ppm	50 ppm	90 ppm		10 ppm	50 ppm	90 ppm
227.0	319.0	282.0	231.0	205.0	219.0	143.0	178.0
57.0	79.8	70.5	58.0	51.3	54.8	35.8	44.5
100.0	140.0	123.7	101.8	100.0	106.8	69.8	86.8
85.0	88.0	76.0	109.0	62.0	64.0	40.0	49.0
21.3	22.0	19.0	27.3	15.5	16.0	10.0	12.3
100.0	103.3	89.2	128.2	100.0	103.2	64.5	79.4
32.0	40.0	24.0	30.0	15.0	6.0	5.0	11.0
8.0	10.0	6.0	7.5	3.8	1.5	1.3	2.8
100.0	125.0	75.0	93.8	100.0	39.5	34.2	73.9
8.0	21.0	4.0	3.0	24.0	6.0	4.0	1.0
2.0	5.3	1.0	0.75	6.0	1.5	1.0	0.3
100.0	265.0	50.0	37.5	100.0	25.0	16.7	5.0

The same experiment was repeated with different dilutions ranging from 10^{-3} to 10^{-5}.

The same experiment was repeated with an increase in the virus — Cotoran incubation period to 6 hours and 24 hours.

The effect of storing the virus for 30 minutes, 6 hours and 24 hours with 10, 50 and 90 ppm Dicuran and 10, 90, 200 and 330 ppm Patoran at dilutions of 10^{-1}, 10^{-2}, 10^{-3} and 10^{-4} was determined using the same technique and design as was applied in the case of Cotoran. Five leaves were used for each treatment in the case of Patoran instead of 4, since there are four concentrations of the compound besides the control.

Effect of herbicides on virus infectivity in vivo

This experiment was planned to study the effect of the above-mentioned concentrations of herbicides on the infectivity of the virus *in vivo* by floating inoculated detached leaves of *D. metel* on different concentrations of herbicides 24 hours before and after inoculation with the virus.

The expressed sap containing the virus was diluted to 10^{-1}. At this dilution a usable number of local lesions was generally produced on *Datura metel* leaves. The effect of the previously mentioned concentrations of each herbicide together with a corresponding control was tested in a separate experiment.

For preinoculation treatment, the method of WEINTRAUB *et al.* (1952) was used with some modifications. Detached leaves of *Datura metel* distributed according to the Latin square design were floated in Petri dishes containing 25—30 ml of the test compound, while the

Table 2

Effect of various concentrations of Dicuran on the number of local lesions

Dilution of virus	Different figures for the number of local lesions	Number of local lesions			
		Control	Virus treated with various concentrations of Dicuran for half an hour		
			10 ppm	50 ppm	70 ppm
10^{-1}	Total (for 4 leaves)	195.0	201.0	173.0	153.0
	Mean No./leaf	49.0	50.3	34.3	38.3
	Mean percentage of control	100.0	102.7	69.7	78.2
10^{-2}	Total (for 4 leaves)	84.0	77.0	50.0	34.0
	Mean No./leaf	21.0	19.3	12.5	8.5
	Mean percentage of control	100.0	91.9	59.5	40.5
10^{-3}	Total (for 4 leaves)	42.0	34.0	26.0	14.0
	Mean No./leaf	10.5	8.5	6.5	3.5
	Mean percentage of control	100.0	81.0	62.0	33.3
10^{-4}	Total (for 4 leaves)	13.0	1.0	5.0	1.0
	Mean No./leaf	3.3	0.3	1.3	0.3
	Mean percentage of control	100.0	9.1	39.4	9.1

Table 3

Effect of various concentrations of Patoran on the number of local lesions

Dilution of viruses	Different figures for the number of local lesions	Number of local lesions				
		Control	Virus treated with various concentrations of Patoran for half an hour			
			10 ppm	90 ppm	200 ppm	330 ppm
10^{-1}	Total (for 5 leaves)	315.0	174.0	162.0	175.0	157.0
	Mean No./leaf	63.0	34.8	32.4	35.0	31.4
	Mean percentage of control	100.0	55.2	51.4	55.6	49.8
10^{-2}	Total (for 5 leaves)	60.0	48.0	38.0	58.0	45.0
	Mean No./leaf	12.0	9.6	7.6	11.6	9.0
	Mean percentage of control	100.0	80.0	63.3	96.7	75.0
10^{-3}	Total (for 5 leaves)	27.0	5.0	12.0	7.0	14.0
	Mean No./leaf	5.4	1.0	2.4	1.4	2.8
	Mean percentage of control	100.0	18.5	44.4	25.9	51.9
10^{-4}	Total (for 5 leaves)	17.0	5.0	12.0	7.0	14.0
	Mean No./leaf	3.4	1.0	2.4	1.4	2.8
	Mean percentage of control	100.0	29.4	70.6	41.2	82.4

produced by tomato mosaic virus in vitro on detached leaves of Datura metel

Number of local lesions							
Control	Virus treated with various concentrations of Dicuran for 6 hours			Control	Virus treated with various concentrations of Dicuran for 24 hours		
	10 ppm	50 ppm	70 ppm		10 ppm	50 ppm	70 ppm
142.0	169.0	126.0	150.0	151.0	103.0	175.0	145.0
35.5	42.3	31.5	37.5	38.0	25.8	43.8	36.8
100.0	119.2	88.7	105.6	100.0	67.9	115.3	96.8
82.0	80.0	56.0	82.0	60.0	68.0	61.0	45.0
20.5	20.0	14.0	20.5	15.0	17.0	15.3	11.3
100.0	97.6	68.3	100.0	100.0	113.3	102.0	75.3
26.0	26.0	30.0	10.0	25.0	25.0	20.0	32.0
6.5	6.5	7.5	2.5	6.3	6.3	5.0	8.0
100.0	100.0	115.4	38.5	100.0	100.0	79.4	127.0
30.0	23.0	8.0	2.0	29.0	19.0	22.0	18.0
7.5	5.8	2.0	0.5	7.3	4.8	5.5	4.5
100.0	77.3	26.7	26.7	100.0	65.8	75.3	61.6

produced by tomato mosaic virus in vitro on detached leaves of Datura metel

Number of local lesions									
Control	Virus treated with various concentrations of Patoran for 6 hours				Control	Virus treated with various concentrations of Patoran for 24 hours			
	10 ppm	90 ppm	200 ppm	330 ppm		10 ppm	90 ppm	200 ppm	330 ppm
300	136.0	85.0	208.0	256.0	355	272.0	224.0	321.0	310.0
60	27.2	17.0	41.6	51.6	71	54.4	44.8	64.2	62.0
100	45.3	28.3	69.3	86.0	100	76.6	63.1	90.4	87.3
72	61.0	70.0	64.0	72.0	165	106.0	94.0	128.0	127.0
14.4	12.2	14.4	12.8	14.4	33	21.2	18.8	25.6	25.4
100	84.7	97.2	88.9	100.0	100	64.2	57.0	77.6	77.0
30	24.0	10.0	19.0	23.0	61	42.0	31.0	38.0	49
6	4.8	2.0	3.8	4.6	12.2	8.4	6.2	7.6	9.8
100	80.0	33.3	63.3	76.7	100	68.9	50.8	62.3	80.3
10	5.0	10.0	7.0	10.0	21	8.0	8.0	0.0	0.0
2	1.0	2.0	1.4	2.0	4.2	1.6	1.6	0.0	0.0
100	50.0	100.0	70.0	100.0	38.1	38.1	0.0	0.0	0.0

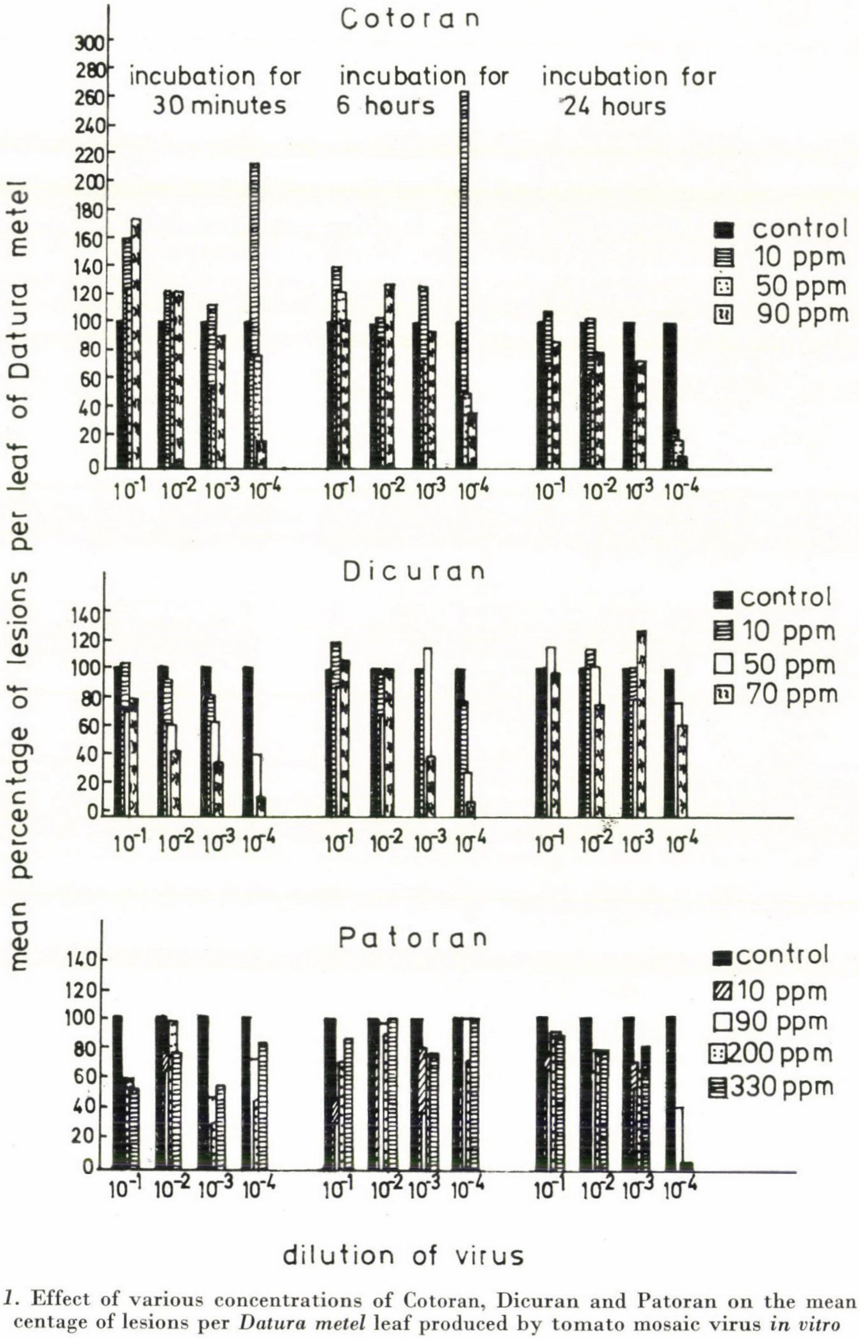

Fig. 1. Effect of various concentrations of Cotoran, Dicuran and Patoran on the mean percentage of lesions per *Datura metel* leaf produced by tomato mosaic virus *in vitro*

corresponding control leaves were floated in dishes containing distilled water. After 24 hours the leaves were removed, washed thoroughly to prevent possible surface inactivation of the virus, and blotted gently. Each leaf was then rubbed with the virus solution, the same number of strokes of the finger being applied to each leaf. The leaves were then rinsed immediately, and replaced in their respective Petri dishes.

For postinoculation treatment, the leaves were inoculated immediately after separation from the plant. They were then rinsed and floated on the test compound immediately after inoculation with the virus. The corresponding control leaves were floated on water.

Effect of herbicides on virus infectivity in vitro

Effect of Cotoran. The effect of 10, 50 and 90 ppm Cotoran on the number of local lesions produced by the virus on detached *Datura metel* leaves are represented in Table 1 and Fig. 1.

The different concentrations of Cotoran stimulated virus infectivity to a different extent. The mean number of lesions per leaf produced by the virus at a dilution of 10^{-1} after 30 minutes treatment with 10, 50 and 90 ppm increased up to 159.1, 123.3 and 171.6% of the control respectively. Stimulation gradually decreased after increasing the virus-Cotoran incubation period up to 6 hours and 24 hours. The mean number of local lesions per leaf gradually decreased till it reached 106.8, 69.8 and 86.8% of the control respectively. The number of local lesions produced at 50 ppm Cotoran usually decreased more than that produced at 10 ppm but it increased again at 90 ppm. The number of local lesions usually decreasing dilution of the virus up to 10^{-2}, 10^{-3} and 10^{-4}.

Effect of Dicuran. The effect of 10, 50 and 70 ppm Dicuran on the infectivity of the virus is represented in Table 2 and Fig. 1.

Dicuran sometimes stimulated lesion production by the virus, but the stimulation was less than that produced by Cotoran.

The mean number of lesions per leaf produced by the virus at a dilution of 10^{-1}, after half an hour's incubation with 10, 50 and 70 ppm, was 102.7, 69.7 and 78.2% of the control respectively. After 6 hours incubation, the mean number of lesions per leaf increased up to 119.2, 88.7 and 105.6% of the control, then it became 67.9, 115.3 and 96.8% of the control after incubation with Dicuran for 24 hours.

Effect of Patoran. The effect of 10, 90, 200 and 330 ppm Patoran on the infectivity of the virus is represented in Table 3 and Fig. 1.

The above-mentioned concentrations of Patoran caused a reduction in the number of local lesions produced by the virus on detached *Datura metel* leaves.

The mean number of lesions per leaf produced by the virus at a dilution of 10^{-1}, after half an hour's incubation with 10, 90, 200 and 330 ppm was 55.2, 51.4, 55.6 and 49.8% of the control respectively. Increasing the incubation period to 6 hours, then to 24 hours showed no definite or constant effect on lesion production by the virus at different dilutions. The mean number of lesions generally increased with an increase in the incubation period but sometimes it decreased. The number of lesions also decreased generally after increasing the dilution of the virus, but here again it sometimes increased.

Effect of herbicides on virus infectivity in vivo

The in vivo effect of pre- and postinoculation treatments with 10, 50 and 90 ppm Cotoran, 10, 50 and 70 ppm Dicuran and 10, 90, 200 and 330 ppm Patoran on the number of local lesions produced by the virus when diluted to 10^{-1} is represented in Table 4 and Fig. 2.

Cotoran, Patoran and Dicuran were very effective in reducing the number of lesions in vivo both before and after inoculation, but they were less effective after inoculation than before.

Pre-inoculation treatment with 10, 50 and 90 ppm Cotoran reduced the mean number of lesions to 61.8, 61.8 and 59.1% of the control respectively. Postinoculation treatment reduced the mean number of lesions to 84.6, 61.5 and 50% of the control respectively.

Preinoculation treatment with 10, 50 and 70 ppm Dicuran reduced the mean number of lesions to 39.5, 26.3 and 15.8%, while postinoculation treatment reduced it to 44.4, 31.5 and 24.1%.

Preinoculation treatment with 10, 90, 200 and 330 ppm Patoran reduced the mean number of lesions to 46, 33.7, 42.9 and 22.7% of the control respectively, while postinoculation treatment reduced it to 46.4, 38.6, 63.6 and 33.6%.

The most effective herbicide both in pre- and postinoculation treatments was Dicuran, followed by Patoran, then Cotoran.

Since neither Cotoran nor Dicuran markedly inactivated tomato mosaic virus *in vitro* (on the contrary they sometimes activated it), it would appear that both herbicides exert

Table 4

Effect of various concentrations of Cotoran, Dicuran and Patoran on the number of local lesions produced by tomato mosaic virus in vivo on detached leaves of Datura metel

Herbicide	Different figures for the number of local lesions	Number of local lesions							
		Control	Preinoculation treatment with			Control	Postinoculation treatment with		
			10 ppm	50 ppm	90 ppm		10 ppm	50 ppm	90 ppm
Cotoran	Total (for 4 leaves)	44	27.0	27.0	26.0	52	44.0	32.0	26.0
	Mean No./leaf	11	6.8	6.8	6.5	13	11.0	8.0	6.5
	Mean percentage of control	100	61.8	61.8	59.1	100	84.6	61.5	50.0

		Control	10 ppm	50 ppm	70 ppm	Control	10 ppm	50 ppm	70 ppm
Dicuran	Total (for 4 leaves)	76	30.0	20.0	12.0	108	48.0	34.0	26.0
	Mean No./leaf	19	7.5	5.0	3.0	27	12.0	8.5	6.5
	Mean percentage of control	100	39.5	26.3	15.8	100	44.4	31.5	24.1

		Control	10 ppm	90 ppm	200 ppm	330 ppm	Control	10 ppm	90 ppm	200 ppm	330 ppm
Patoran	Total (for 5 leaves)	163.0	60	55.0	70.0	37.0	140	65.0	54.0	89.0	47.0
	Mean No./leaf	32.6	15	11.0	14.0	7.4	28	13.0	10.8	17.8	9.4
	Mean percentage of control	100.0	46	33.7	42.9	22.7	100	46.4	38.6	63.6	33.6

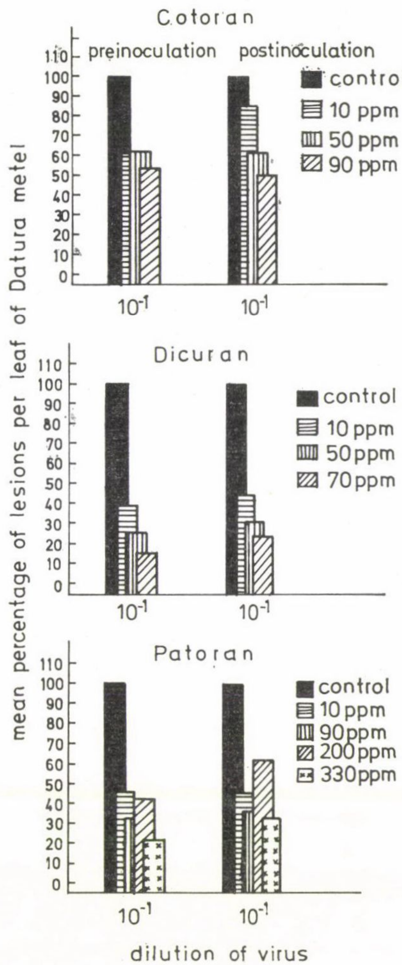

Fig. 2. Effect of various concentrations of Cotoran, Dicuran and Patoran on the mean percentage of lesions per *Datura metel* leaf produced by tomato mosaic virus *in vivo*

their inhibitory effect, not upon the virus directly, but probably through some interaction with host tissues (MATTHEWS 1970). Hence, their inhibitory effect is higher in the case of preinoculation treatment than postinoculation treatment. Since Patoran inhibited the virus infectivity both *in vivo* and *in vitro*, it can be deduced that the inhibitory effect is possible due to its action on the host as well as on the virus.

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Prepared at the Botany Department, Faculty of Science, Cairo University, Cairo

H. M. HABIB, J. K. ESKAROUS, M. H. ISMAIL

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SEEDLING GROWTH AND COLD TOLERANCE OF DIFFERENT MAIZE GENOTYPES

In general, cold tolerance ratings are based exclusively on percentage germination or emergence. To take advantage of the early growing season, however, cold tolerant maize must not only germinate and emerge well, but it must also grow normally. Therefore, cold tolerance ratings must include: stand, emergence rate and seedling growth (MOCK—EBERHART 1972).

Wide variations have been found among maize lines for germination below 10 °C and the rate of seedling growth at 13 to 16 °C (GROGAN 1970). MISHUSTINA (1969) observed that

Table 1

Effect of cold wave on plant height
(cm)

Genotypes	Control					Low temperature treatment on		
	1	2	3	4	5	1	2	3
	week old plants							
Inbred lines								
B 125	18.3	34.0	58.0	60.3	99.0	14.8	34.3	54.0
B 18/4	9.3	26.8	47.0	48.5	77.7	14.0	28.3	39.5
Be03 b	6.3	19.5	33.0	39.0	76.7	9.5	21.5	33.0
N6	8.5	21.3	38.0	37.5	78.7	12.3	23.5	37.8
HMV 403	12.0	23.5	44.8	53.5	86.0	13.5	31.4	50.8
Cs 187	17.5	26.5	40.8	63.3	85.0	18.8	36.5	42.4
Single crosses								
HMV 403 × Cs 187 (Mv Sc 450)	18.8	30.8	59.0	68.0	103.7	17.5	48.8	41.0
B 125 × B 18/4	17.8	36.3	62.3	71.3	102.3	16.5	38.5	57.5
Be03 b × N6	11.3	32.0	56.8	71.0	107.0	17.3	43.3	64.3
Double cross								
B 125 × B 18/4 × Be03 b × N6 (Mv Dc 460)	12.8	33.8	62.5	71.3	106.3	18.0	38.3	49.3
Means								
Inbreds	12.0	25.3	43.6	50.4	83.9	13.8	29.3	42.9
Single crosses	16.0	33.0	59.4	70.1	103.4	17.1	43.5	57.6
$LSD_{5\%}$	2.9	4.2	7.8	6.9	11.1	3.3	6.9	11.0

Table 2

Effect of cold wave on number of leaves
(leaves/plant)

Genotypes	Control					Low temperature treatment on		
	1	2	3	4	5	1	2	3
	week old plants							
Inbred lines								
B 125	4.8	6.0	6.8	7.0	7.0	6.0	5.0	7.0
B 18/4	4.3	5.5	5.8	6.0	6.6	6.0	4.3	6.0
Be03 b	4.0	4.0	4.8	6.3	6.3	5.5	3.5	5.5
N6	3.8	4.5	5.5	6.0	7.6	5.5	4.5	6.3
HMV 403	4.5	5.5	5.8	6.5	6.6	6.0	5.0	6.0
Cs 187	4.5	5.5	5.8	6.8	7.0	6.0	5.3	6.3
Single crosses								
HMV 403×Cs 187 (Mv Sc 450)	4.8	6.0	7.0	7.0	8.0	6.0	5.3	6.0
B 125×B 18/4	4.8	6.0	7.0	7.3	7.3	6.0	5.0	6.5
Be03 b×N6	4.8	5.0	6.5	7.5	8.0	6.0	5.5	7.3
Double cross								
B 125×B 18/4×Be03 b×N6 (Mv Dc 460)	5.0	6.0	7.0	7.0	8.0	6.0	5.0	6.0
Means								
Inbreds	4.3	5.2	5.8	6.4	6.9	5.8	4.6	6.2
Single crosses	4.8	5.7	6.8	7.3	7.8	6.0	5.3	6.6
$LSD_{5\%}$	0.6	0.9	0.6	0.2	0.8	0.7	1.1	0.8

non-cold resistant maize hybrids have reduced contents of chlorophyll *a* and *b* at 2 to 6 °C. This finding is in good agreement with the results obtained here. Genotypes differed significantly in their morphological characters and in their tolerance to cold waves. These results were in line with those of LUKSA (1967) and GERASIMOV (1973). The harmful effect of the cold wave varied for the different genotypes. The use of a cold wave retarded plant height, number of leaves, green leaves percentage, fresh and dry weight and total chlorophyll content. The same results were obtained by GUPTA—KOVÁCS 1974, 1975 and JENKINS—ROFFEY 1974.

One of the major environmental factors limiting the range of adaptation for maize (*Zea mays* L.) is low temperature, especially low air and soil temperatures at planting time. At many high latitudes and high altitudes of the world, potential maize yields could be enhanced if maize genotypes of full-season maturity could be planted earlier than the traditional planting dates. This yield increase would result from the full-season genotypes using more solar energy throughout the growing season. Furthermore, early planting of maize in the central latitudes followed by normal growth and development of the plants would result in near-coincidence of the grain-filling period of the crop with the period of highest light intensity for the growing season. Consequently, more photosynthate would potentially be available for deposition in the grain. All these ideas require that maize genotypes be tolerant of cold temperatures during seed germination, seedling emergence and early plant growth (MOCK—SKRDLA 1978).

It is well known that maize has tremendous variability in its ability to germinate at low temperatures (PINNELL 1949, LUDWIG *et al.* 1957, GUPTA—KOVÁCS 1974, 1975). According to SACHS (1865) maize is quite yellow at growing temperatures below 14 °C, the disturbance being in chloroplast differentiation.

Data have also been presented by a few researchers on the ability of maize to grow at below optimum temperatures and on the growth of seedlings under cool natural conditions (PESEV 1969, GROGAN 1970, MOCK—EBERHART 1972, MOCK—SKRDLA 1978).

The study consists of one double cross developed at Martonvásár, namely Mv 460 (B 125×B 18/4×Be03b×N6), three single crosses, namely HMV 403×Cs 187 (MVSc 450), B 125×B 18/4 and Be03b×N6, and six inbred lines: B 125, B 18/4, Be03b, N6, HMV 403 and Cs 187. This means that 10 different genotypes were used in the experiments. Seeds from the different genotypes were germinated on moist sheets of filter paper in a germination incubator and planted in 10 cm plastic pots filled with three parts loam soil with high organic matter and one part sand. 33 pots were planted for each genotype. The pots were placed in a growth

Table 3

Effect of cold wave on percentage of green leaves

Genotypes	Control		Low temperature treatment on		
	2	4	1	2	3
	week old plants				
Inbred lines					
B 125	96	100	96	100	100
B 18/4	92	96	83	100	96
Be03 b	92	100	96	79	100
N6	92	96	91	50	80
HMV 403	100	100	92	100	100
Cs 187	93	96	58	71	84
Single crosses					
HMV 403×Cs 187 (Mv Sc 450)	89	93	92	71	58
B 125×B 18/4	86	100	100	75	39
Be03 b×N6	100	88	88	55	48
Double cross					
B125×B 18/4×Be03 b×N6 (Mv Dc 460)	93	93	79	60	67
Means					
Inbreds	94	98	86	83	93
Single crosses	92	94	93	67	48

Table 4

Effect of cold wave on fresh weight of maize
(g/plant)

Genotypes	Control		Low temperature treatment on	
	2	4	2	3
	week old plants			
Inbred lines				
B 125	16.42	34.52	8.11	15.40
B 18/4	12.35	25.16	8.01	12.58
Be03 b	9.52	23.72	9.32	10.40
N6	8.17	27.45	6.21	9.45
HMV 403	14.25	34.28	11.40	15.45
Cs 187	14.38	24.16	11.22	13.55
Single crosses				
HMV 403 × Cs 187 (Mv Sc 450)	16.75	49.25	12.85	14.45
B 125 × B 18/4	15.48	48.26	12.40	14.27
Be03 b × N6	16.63	49.35	12.46	15.24
Double cross				
B 125 × B 18/4 × Be03 b × N6 (Mv Dc 460)	15.26	45.16	13.65	16.85
Means				
Inbreds	12.52	28.22	9.05	12.81
Single crosses	16.29	48.95	12.57	14.65

chamber at 25 °C during the day and 12 °C at night for five weeks and this chamber was considered as the control. After the first week, and till the fourth week, ten seedlings from each genotype were transferred to 12 °C during the day and 3 °C at night for one week (cold wave), and after that five seedlings from each genotype were put back into the growth chamber at 25 °C/12 °C. Other seedlings were taken for the morphological and chlorophyll analyses.

The investigation is designed to study the effect of a cold wave at three stages of growth on the morphological characteristics of different maize genotypes and the per cent regenerating ability of the treated genotypes.

The experiment was conducted in 1978 in the phytotron of the Agricultural Research Institute of the Hungarian Academy of Sciences at Martonvásár. For the chlorophyll analysis the authors are gratefully indebted to Dr Márta Dévay and her staff.

The effect of genotypes, cold wave and periods on plant height is demonstrated in Table 1.

The results are grouped into inbred lines, single crosses and double cross, and the mean of every group is given. It will be seen that there are significant differences within the inbred lines and single crosses between the different periods. Also a clear difference was observed between the three groups studied.

The stage of growth also influences the tolerance of the plant to a cold wave. In general it is important to note that the older seedlings were more tolerant than younger ones. The same trend was observed for the number of leaves/plant in Table 2.

The effect of the cold wave on the percentage of green leaves per plant was calculated from the formula:

$$\frac{\text{green leaves/plant}}{\text{total leaves/plant}} \times 100$$

and is demonstrated in Table 3. The percentage of green leaves varied within the different genotypes and also between the three groups. It could be observed that after a low temperature period the green leaves per cent was larger in the inbred lines in comparison with the single or double cross at the same stage of growth. One week of cold wave treatment at a somewhat later stage of growth was worse for the seedlings than the same treatment given at an earlier stage. When the seedlings were grown for two weeks in a growth chamber and after that treated with a cold wave for one week, or treated in the fourth week to a warm wave, the green leaves percentage was badly affected. A cold wave at any stage of growth had a harmful effect on both the dry and fresh weight compared to the control (Tables 4, 5).

Table 5

Effect of cold wave on dry weight of plants
(g/plant)

Genotypes	Control	Low temperature treatment on	
	4	2	3
	week old plants		
Inbred lines			
B 125	1.97	0.73	1.72
B 18/4	1.35	0.82	1.28
Be03 b	1.03	0.90	1.16
N6	1.02	0.67	1.04
HMV 403	1.87	0.98	1.78
Cs 187	1.95	1.05	1.52
Single crosses			
HMV 403 × Cs 187 (Mv Sc 450)	1.60	0.96	1.59
B 125 × B 18/4	1.54	1.04	1.57
Be03 b × N6	1.72	1.06	1.71
Double cross			
B 125 × B 18/4 × Be03 b × N6 (Mv Dc 460)	1.67	1.09	1.78
Means			
Inbreds	1.53	0.85	1.42
Single crosses	1.62	1.02	1.62

Table 6

Effect of cold wave on chlorophyll a and b content
(mg/g fresh weight)

Genotypes	Control						Low temperature treatment on			
	1		2		5		1		2	
	week old plants									
	a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
Inbreds										
B 125	0.47	0.28	0.45	0.22	0.16	0.13	0.51	0.31	0.37	0.21
B 18/4	0.40	0.13	0.38	0.13	0.22	0.14	0.58	0.55	0.28	0.14
Be03 b	0.66	0.21	0.40	0.20	0.26	0.20	0.57	0.50	0.31	0.15
N6	0.35	0.15	0.41	0.21	0.14	0.11	0.47	0.27	0.28	0.27
HMV 403	0.53	0.41	0.52	0.31	0.23	0.18	0.55	0.30	0.30	0.38
Cs 187	0.23	0.07	0.42	0.22	0.29	0.34	0.41	0.39	0.29	0.30
Single crosses										
HMV 403 × Cs 187 (Mv Sc 450)	0.49	0.34	0.43	0.23	0.23	0.16	0.59	0.17	0.28	0.25
B 125 × B 18/4	0.48	0.30	0.39	0.28	0.28	0.25	0.54	0.22	0.29	0.27
Be03 b × N6	0.20	0.06	0.44	0.18	0.29	0.31	0.59	0.36	0.23	0.14
Double cross										
B 125 × B 18 × × Be03 B × N6 (Mv Dc 460)	0.49	0.33	0.50	0.28	0.21	0.14	0.55	0.54	0.30	0.31
Means										
Inbreds	0.44	0.21	0.43	0.22	0.22	0.18	0.53	0.39	0.29	0.24
Single crosses	0.39	0.23	0.49	0.23	0.27	0.24	0.51	0.25	0.27	0.22

It can also be observed that the early application of a cold wave gave the worst effect. Maize seedlings were more tolerant to a cold wave in the later stages of growth than in the earlier stages.

From Table 6 it will be seen that both chlorophyll *a*, chlorophyll *b*, and the total chlorophyll content of the leaves were affected by the genotypes and by the cold wave. The low temperature decreased the total chlorophyll content as the growth stage increased, but on the other hand the total chlorophyll content for all the plant was increased for the increasing rate of fresh weight in the different growth stages. It can also be observed that when maize seedlings were treated with a cold wave in an earlier stage no harmful effect was obtained when compared with seedlings treated at later stages. The chlorophyll content differed within the genotypes, and between the three groups studied. Generally, hybrids show more sensivity to cold wave treatment than inbred lines.

It is evident from Tables 7, 8 and 9 that the per cent regenerating ability differed between the genotypes, periods and the character studied. Generally, hybrids had better regenerating ability than inbreds in plant height. Maize seedlings treated with a cold wave in later stages were more tolerant than those treated earlier. Therefore, the regenerating ability increased in the later stages of growth.

From Tables 8 and 9 it will be seen that inbred lines had better regenerating ability than hybrids for the number of leaves and the fresh weight/plant. This may be due to the fact that the fresh weight and number of leaves is larger for maize hybrids than for inbred lines.

Generally, it could be concluded that the per cent regenerating ability for the studied characters, or in other words the tolerance of the treated plants to the cold wave effect, varied according to the growth stage and the genotype. Seedlings treated with a cold wave in a later growth stage were able to regenerate or renew the injured character or organ more rapidly and with less harmful effect than those treated in an earlier stage.

In general it is evident that maize inbreds or hybrids are more sensitive to cold temperature in the earlier stages of growth than in the later stages. This can be explained by the relation between the tolerance of maize seedlings to a cold wave and the water content or dry matter content.

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Prepared at the Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvásár

T. A. Hussein

Table 7

Regenerating ability of different maize genotypes after a cold wave
(plant height compared with the control as per cent)

Genotypes	Low temperature treatment on					
	1			2		3
	week old plants					
	Regeneration time, weeks					
	1	2	3	1	2	1
Inbred lines						
B 125	48	70	85	72	70	78
B 18/4	57	82	83	73	79	87
Be03 b	51	76	77	62	77	89
N6	55	82	90	85	82	91
HMV 403	52	64	65	76	81	70
Cs 187	58	63	85	68	64	85
Single crosses						
HMV 403×Cs 187 (Mv Sc 450)	53	72	72	84	77	91
B 125×B 18/4	57	70	89	73	70	93
Be03 b×N6	61	69	91	85	81	97
Double cross						
B 125×B 18/4×Be03 b×N6 (Mv Dc 460)	51	65	80	63	72	82
Means						
Inbreds	53.5	72.8	80.8	72.7	75.5	83.3
Single crosses	57.0	70.3	84.0	80.7	76.0	93.7

Table 8

Regenerating ability of different maize genotypes after a cold wave
(number of leaves/plant compared with the control as per cent)

Genotypes	Low temperature treatment on					
	1			2		3
	week old plants					
	Regeneration time, weeks					
	1	2	3	1	2	1
Inbred lines						
B 125	74	86	100	93	90	100
B 18/4	74	100	98	97	80	114
Be03 b	73	84	87	76	68	95
N6	82	100	92	97	83	92
HMV 403	83	92	83	92	106	83
Cs 187	86	97	93	88	80	93
Single crosses						
HMV 403 × Cs 187 (Mv Sc 450)	71	90	94	93	79	94
B 125 × B 18/4	69	90	103	86	86	96
Be03 b × N6	77	88	106	84	91	100
Double cross						
B 125 × B 18/4 × Be03 b × N6 (Mv Dc 460)	71	90	94	79	95	94
Means						
Inbreds	79	93	92	91	85	96
Single crosses	72	89	101	88	85	97

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Table 9

Regenerating ability of different maize genotypes after a cold treatment
(fresh weight/plant compared with the control as per cent)

Genotypes	Low temperature treatment on 1		2		3
	week old plants				
	Regeneration time, weeks				
	2	3	1	2	1
Inbred lines					
B 125	80	42	82	53	82
B 18/4	83	47	92	78	81
Be03 b	97	41	97	49	83
N6	103	33	105	49	75
HMV 403	84	33	90	36	62
Cs 187	94	52	84	67	82
Single crosses					
HMV 403 × Cs 187 (Mv Sc 450)	88	27	89	33	62
B 125 × B 18/4	85	27	85	38	71
Be03 b × N6	87	30	85	33	79
Double cross					
B 125 × B 18/4 × Be03 b × N6 (Mv Dc 460)	96	34	97	43	91
Means					
Inbreds	90	41	92	55	78
Single crosses	87	28	86	35	71

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EFFECT OF VARIETY, SOWING DATE AND NITROGEN ON KENAF YIELDS IN THE KENANA AREA OF THE SUDAN

Kenaf (*Hibiscus cannabinus* L.) was introduced into the Sudan in 1960 as a possible source of soft fibre. The crop exhibited a marked sensitivity to daylength, with a great deal of variation between varieties in this respect. Accordingly, it was possible to use early and late maturing varieties so as to extend the harvest over a longer period.

In Cuba, Crane—Acuna (1945) and Crane *et al.* (1946) found that kenaf can be planted for fibre from April or May until the middle of July. They determined that the height and the amount of fibre per plant at blossoming time became successively smaller as the planting date was delayed during the period May to August. In some cultural experiments with kenaf in Cuba. Walker—Sierra (1950) found that the highest yield of fibre was obtained from a June planting in 1946 and a May planting in 1947. In the Philippines Cruz (1952) recommended planting kenaf for fibre production from April to July. In Florida, Seale *et al.* (1954) reported that the greatest vegetation and yield of fibre was obtained from May and June plantings.

Whiteley (1971) and Saleem (1966) showed that in most years the yield of dry matter and dry ribbon decreased with plantings later than mid-May.

In Florida, Seale *et al.* (1952) found that the yield of green stalks and fibre was significantly increased by the application of nitrogen fertilizer. Jackson (1964) reported that the kenaf plant showed a great response to nitrogen fertilization, and the application of 43 kg of nitrogen per hectare gave a nearly 50% increase in total green yield and 25% in dry ribbon yield over no nitrogen under rain at Tonj, Sudan. Saleem (1967) obtained an increase of 11% in dry ribbon yield with the application of 43 kg nitrogen per hectare as compared to the no nitrogen treatment.

Table 1

Three year summary of the effects of sowing date, nitrogen rates and varieties on an established kenaf plant population

(1000 plants/ha)

Variety	Sowing date	Nitrogen rates, kg/ha			Mean (V×S)
		0	43	86	
	May 15	464	483	457	469
G. 58	June 15	597	590	592	592
	July 15	497	485	419	466
	May 15	443	457	407	435
G. 40	June 15	488	414	507	469
	July 15	609	590	581	592
			(±41.4)		(±16.9)
Mean (V×N)	G. 58	519	519	490	509
	G. 40	514	488	497	500
			(±16.9)		(±9.8)
	May 15	452	709	431	452
Mean (S×N)	June 15	543	502	550	531
	July 15	554	538	500	528
			(±20.7)		(±11.9)
Mean (N)		516	502	495	504
			(±11.9)		

WILLIAMS (1966) studied the effects of different nitrogen levels on dry matter yields of kenaf under irrigated and rain-fed tests and found that the application of nitrogen in the rain-fed tests did not significantly increase the dry matter yield. In the irrigated tests small and statistically non-significant increases in dry matter were obtained with increasing nitrogen application up to 100 pounds per acre.

The objective of the investigation reported in this paper was to determine the effect of time of planting and nitrogenous fertilizer on the growth and yield of ribbons of two varieties of kenaf.

The experiment was conducted in three seasons on a heavy clay soil with a pH of about 8.5 at the Kenana Research Farm. In each year three sowing dates (mid-May, mid-June and mid-July), two varieties (G. 58 and G. 40) and three rates of nitrogen (0, 43 and 86 kg per hectare) were tested in a $3\times2\times3$ factorial experiment in a randomized complete block design replicated four times.

The nitrogen carrier was ammonium sulphate applied at planting time. Seed was sown with a hand-driven drill in rows 30 cm apart at a rate of 21.5 kg per hectare.

Each year all treatments received a presowing watering and were irrigated immediately after sowing. From then onwards, watering continued fortnightly except when there was adequate rainfall.

Each treatment was harvested when an average of about 10 flowers per plant were in bloom. The stems were cut near ground level and tied into bundles. After recording the total

Table 2

Three year summary of the effects of sowing date, nitrogen rates and varieties on kenaf plant height (cm/plant)

Variety	Sowing date	Nitrogen rates, kg/ha			Mean (V×S)
		0	43	86	
	May 15	222	237	241	233
G. 58	June 15	194	201	204	200
	July 15	150	162	169	160
	May 15	242	242	255	246
G. 40	June 15	216	241	241	233
	July 15	173	188	201	187
			(±3.48)		(±2.84)
Mean (V×N)	G. 58	189	200	205	198
	G. 40	210	224	232	222
			(±2.84)		(±1.64)
	May 15	232	240	248	239
Mean (S×N)	June 15	205	221	222	216
	July 15	162	175	185	174
			(±3.48)		(±2.01)
Mean (N)		200	212	218	210
			(±2.01)		

Table 3

Three year summary of the effects of sowing date, nitrogen rates and varieties on kenaf stem diameter (mm)

Variety	Sowing date	Nitrogen rates, kg/ha			Mean (V×S)
		0	43	86	
	May 15	9.8	10.4	10.2	10.1
G. 58	June 15	8.1	9.3	9.3	8.9
	July 15	6.5	6.9	7.3	6.9
	May 15	10.7	11.4	11.4	11.2
G. 40	June 15	9.2	10.1	10.7	10.0
	July 15	7.0	7.9	8.1	7.7
			(±0.23)		(±0.19)
Mean (V×N)	G. 58	8.1	8.9	8.9	8.6
	G. 40	9.0	9.8	10.1	9.6
			(±0.19)		(±0.11)
	May 15	10.2	10.9	10.8	10.6
Mean (S×N)	June 15	8.7	9.7	10.0	9.5
	July 15	6.7	7.4	7.7	7.3
			(±0.23)		(±0.43)
Mean (N)		8.5	9.4	9.5	9.1
			(±0.43)		

fresh weight, the leaves and flowers were removed to obtain the green stalk yield. These two operations were carried out immediately after cutting the stalks. A hand-fed decorticator was then used to separate the bark from the wood. Other observations included stand counts at harvest time, stalk diameter and sun dry ribbon yields.

Seasonal variation. Before proceeding with the computations of the combined analysis of 3 years, Bartlett's homogeneity test was made for the error variances of the three years.

Except for total fresh yield and plant height, all the characters studied showed significant variations between years. For example, it was found that the kenaf dry ribbon yield per hectare was 2889, 3282 and 3894 kg for the first, second and third season, respectively. Differences between years for established plant populations at harvest time were significant, the means being 476,000, 549,780 and 497,420 plants per hectare, respectively. Stem diameters at 30 cm above the soil surface for the first, second and third season were 9.7, 9.9 and 7.8 mm, respectively.

It was natural that kenaf grown under different repeatable treatments could not be considered to respond to seasonal effects to the same extent. It was difficult to limit the factors causing this seasonal variation. All levels of treatments had or tended to have the same effect on all the characters studied from year to year. So the combined analysis of the three years or the three year average will be presented for each of the five characters studied.

Established plant population. There were significant differences between the sowing dates in plant populations at harvest. The June and July sowing dates had significantly higher plant populations than the May sowing date (Table 1). This was due to the suitability of the environmental conditions to the growth of kenaf. These conditions include high relative humidity, optimum mean day temperature, short days, and ample soil moisture for kenaf growth. Also, the splashing of rainwater caused soil clods to break up in the June and July sowing plots. So the drilled seeds would have a fine seed bed for germination. Also, plants sown in May suffered greater damage from repeated injury by the flea beetle, *Podagrica puncticollis.*

Differences in plant populations were not affected significantly by varieties or nitrogen application. The plant population in the control was 4% higher than that in the 86 kg N per ha treatment.

The interaction of sowing date and variety was significant. The plant population of the variety G. 40 progressively increased with a delay in sowing date. G. 58 had the highest plant population in the mid-June sowing. The interaction between variety and nitrogen application was not significant.

Plant height. Plant height showed highly significant ($P = 0.01$) variations between the different sowing dates. The plant height of both varieties decreased progressively with a delay in sowing date after mid-May (Table 2). G. 40 was taller than G. 58 at all sowing dates

Table 4

Three year summary of the effects of sowing date, nitrogen rates and varieties on kenaf total fresh yield
(metric tons/ha)

Variety	Sowing date	Nitrogen rates, kg/ha 0	43	86	Mean (V×S)
	May 15	48.8	55.0	60.7	54.8
G. 58	June 15	43.8	54.5	60.2	52.8
	July 15	23.8	33.8	38.3	32.0
	May 15	50.0	56.2	65.7	57.3
G. 40	June 15	45.7	54.5	56.9	52.4
	July 15	30.0	40.2	41.9	37.4
			(±1.28)		(±1.05)
Mean (V×N)	G. 58	38.8	47.6	53.1	46.5
	G. 40	41.9	50.2	54.7	48.9
			(±1.05)		(±0.59)
	May 15	49.3	55.4	63.1	55.9
Mean (S×N)	June 15	44.7	54.5	58.5	52.6
	July 15	26.9	37.1	40.0	34.7
			(±1.28)		(±0.74)
Mean (N)		40.5	48.8	53.8	47.7
			(±0.74)		

Table 5

Three years summary of effects of sowing date, nitrogen rates and varieties of kenaf dry ribbon yield
(kg/ha)

Variety	Sowing date	Nitrogen rates, kg/ha			Mean (V×S)
		0	43	86	
	May 15	3720	4105	4315	4047
G. 58	June 15	2963	3639	3753	3452
	July 15	1471	1856	2011	1779
	May 15	3817	4232	4570	4206
G. 40	June 15	3613	4251	4301	4055
	July 15	2216	2739	2887	2614
			(±88)		(±72)
Mean (V×N)	G. 58	2718	3201	3361	3093
	G. 40	3215	3741	3920	3625
			(±72)		(±41)
	May 15	3770	4167	4441	4126
Mean (S×N)	June 15	3287	3946	4027	3753
	July 15	1844	2299	2449	2197
			(±87)		(±51)
Mean (N)		2967	3471	3639	3360
			(±51)		

Plant height was significantly (P = 0.01) increased by nitrogen application over no nitrogen, but there was no difference in effect between 43 and 86 kg N/ha. Even though the interaction of variety×nitrogen was not significant, G. 40 responded better to nitrogen application than G. 58.

Stem diameter. The effects of planting dates, nitrogen levels and varieties on the average stem diameter of kenaf, as averages over three years, are shown in Table 3. The differences in stem diameters between the two varieties and between the sowing dates and nitrogen levels were highly significant (P = 0.05). Stem diameter tended to decrease with successively later dates. Massey (1974b) confirmed this result and found that the basal stem diameter was reduced by later planting in two years of his tests.

G. 40 had a greater stem diameter than G. 58. The stem diameter at 43 kg N/ha was significantly greater than in the no nitrogen control. Both 43 kg/ha and 86 kg/ha of nitrogen gave a similar stem diameter. Massey (1974a) reported that there was an increase in basal stem diameter up to 90 kg N/ha. All the possible interactions were not significant.

Total fresh yield. Yields of total fresh weight were significantly (P = 0.01) affected by variety, sowing date and nitrogen (Table 4). The maximum yield was obtained from the May sowing. The loss in total fresh yield was 8% and 33% with a delay of one month and two months, respectively, from the mid-May sowing data. Massey (1974b) found that the yield tended to decrease with successively late planting dates and was 66% lower in the mid-July planting as compared with the last week of the May planting date. The interaction of variety × sowing date was highly significant (P = 0.01). G. 40 produced a 4.3 and 14.4% increase in total fresh yield over G. 58 in mid-May and mid-June, respectively. Both varieties gave similar yields in mid-June even though G. 40 had a 26% less plant population at this sowing date.

The interaction of variety × nitrogen was not significant but both varieties had the highest yield of fresh matter in the 86 kg N/ha treatment.

Dry ribbon yield. The three year averages for dry ribbon yield as affected by variety, sowing date and nitrogen application are presented in Table 5. The variation in dry ribbon yield due to sowing date was highly significant (P = 0.01). For both varieties the yield was highest in the mid-May sowing and decreased progressively with a delay in sowing. G. 40 significantly (P = 0.01) outyielded G. 58 by 15% and was less affected by delayed sowing.

Differences in dry ribbon yield due to nitrogen application were highly significant. The application of the first 43 kg N/ha gave an average increase of 14.5% in dry ribbon yield over the no nitrogen treatment. Doubling the amount of nitrogen resulted in a further 5% increase in dry ribbon production.

Nitrogen failed to produce any significant effect on the dry ribbon yield of either variety at any of the three sowing dates, and the interactions between fertilizer and variety or sowing date were not significant. Generally both G. 40 and G. 58 had the steepest increases in dry ribbon yield with increases in the nitrogen rates.

Table 6

Three year summary of the effects of sowing date, nitrogen rates and varieties on kenaf ribbon percentage

Variety	Sowing date	Nitrogen rates, kg/ha			Mean (V × S)
		0	43	86	
G. 58	May 15	7.23	7.09	6.93	7.08
	June 15	7.24	7.17	7.00	7.14
	July 15	6.07	6.13	5.93	6.04
G. 40	May 15	6.90	7.09	7.02	7.00
	June 15	7.78	8.02	7.68	7.83
	July 15	6.84	7.09	6.97	6.97
			(±0.01)		(±0.08)
Mean (V × N)	G. 58	6.85	6.80	6.62	6.75
	G. 40	7.18	7.40	7.22	7.27
			(±0.08)		(±0.04)
Mean (S × N)	May 15	7.06	7.09	6.97	7.04
	June 15	7.51	7.59	7.34	7.48
	July 15	6.46	6.61	6.45	6.51
			(±0.09)		(±0.05)
Mean (N)		7.01	7.10	6.92	7.01
			(±0.05)		

The percentage of dry ribbon to green weight. Ribbon percentages varied significantly ($P = 0.01$) with the date of planting. The highest percentage was obtained from the mid-June planting, which was significant compared to those obtained from the mid-May and mid-July plantings. The mid-July planting gave the lowest percentage (Table 6).

The interaction of variety×sowing date was significant. This indicated that the varieties responded differently to variable sowing dates, even though the highest ribbon percentage for each variety was obtained in the mid-June planting.

The calculated ribbon percentages for the mid-May and mid-June planting dates for the variety G. 58 were nearly the same, and both were significantly higher than that obtained from the mid-July planting.

For the variety G. 58 the differences in ribbon percentages between mid-May and mid-July and between mid-June and mid-July reached 14.7% and 15.4% respectively. Ribbon percentages obtained from the mid-May and mid-July plantings of the variety G. 40 were similar and significantly inferior to that of the mid-June planting date. The mid-June plants averaged a 10.6% and 11.0% higher ribbon percentage than those obtained from the mid-May and mid-July planting dates, respectively, for the variety G. 40. The stems of G. 40 contained about 7% more ribbons than those of G. 58.

Nitrogen application had no significant effect on the stem ribbon content. A slight increase of 1.3% was gained with the application of 43 kg N/ha. The interactions of sowing dates × nitrogen and variety × nitrogen were not significant.

The dry ribbon yield data (Table 5) clearly illustrate the beneficial effects of the earlier planting date. Mid-May planting yielded 373 and 1929 kg/ha more than the mid-June and mid-July plantings, respectively. The plants from the mid-May planting had taller stems and thicker stem diameters than those obtained from the mid-June and mid-July planting dates. This was reflected in the total fresh yield.

The variety G. 40 outyielded G. 58 in all the characters studied and at all sowing dates. It was taller, thicker, higher in ribbon percentage and later in flowering by more than two weeks.

The results indicate that for a maximum yield of kenaf ribbons per unit of land in the Kenana area, the crop should be planted under irrigation any time during May. Crane *et al.* (1945) and Walker *et al.* (1960) reported that the vegetative growth and fibre content of kenaf plants are strongly influenced by a cycle of photoperiodism, and also by an adequate amount of moisture, bright sunny days and a well-prepared seed bed.

It is also clear, therefore, that the growing conditions of each region demand the use of varieties with a suitable maturing period (Kirby 1963, Vargas Mendez 1960).

The soils at the Kenana Research Station on which this trial was planted were considered poor in nitrogen. So an increase in dry ribbon yield of 17 and 22% was obtained from the addition of 43 and 86 kg N/ha over the no nitrogen treatment. The application of 43 kg N/ha greatly affected the total fresh weight (20%). This effect was three times the effect of fertilizer on the stem height (6%) and stem diameter (6%). Generally nitrogen is an important major element for the establishment, growth and development of the kenaf crop. Most of the assimilates formed during the growing season were directed to the height of the plant and its thickness. It is also worth mentioning that nitrogen does not move straight to the stem; leaf growth must proceed before stem elongation and the addition of stem diameter.

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Prepared at the Hudeiba Research Station, El-Damer

F. A. Salih

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EFFECT OF PLOIDY DIFFERENCES ON FRUIT CHARACTERISTICS IN WATERMELON

When eating watermelon fruits, it would be much more convenient if there were no troublesome seeds in the flesh.

The seedless watermelon is scientifically the triploid obtained by crossing the pollen of a diploid with the female flowers of tetraploid plants raised by using colchicine.

This investigation was carried out to evaluate the possible production of triploid watermelon through the utilization of various germplasms. It would also be highly desirable if further benefits could be obtained in addition to seedlessness.

Extensive studies on fruit characteristics in polyploid watermelons were reported by KIHARA—NISHIYAMA (1947), KIHARA (1951), MATSUBAYASHI (1954), SHIMOTSUMA (1957), GREEN (1959), WALL (1960), STINO *et al.* (1967) and ABD EL-HAFEZ (1969).

Eleven cultivars of watermelon were used in the present investigation, five diploids, five triploids and one tetraploid. These studies were carried out at the Vegetable Crop Research Station at Giza, Faculty of Agriculture, Cairo University, from 1973 to 1976.

The diploid cultivars, namely Shipper, Congo, Shin Yamato, Giza 1 and Fairfax, were all selfed for several generations before crossing with the tetraploid. Shipper, Shin Yamato and Giza 1 had round fruits, but Congo and Fairfax had long fruits. Shin Yamato and Fairfax fruits were light green with dark green stripes. The other cultivars had dark green or green rind colour.

The tetraploid cultivar, Sugar Baby, was developed in A. R. Egypt from the diploid Sugar Baby by colchicine treatment by Warid and Abd El-Hafez in 1968. The fruit is round with dark green rind. The flesh is red.

The five triploids were obtained by crossing diploid with tetraploid cultivars as follows:

1. Sugar Baby 4x × Shipper 2x
2. Sugar Baby 4x × Congo 2x
3. Sugar Baby 4x × Shin Yamato 2x
4. Sugar Baby 4x × Giza 1 2x
5. Sugar Baby 4x × Fairfax 2x

In the 1976 season, the diploid, triploid and tetraploid cultivars were sown on March 23rd. The following data were recorded on the fruits:

1. Weight, in kg.
2. Diameter and length, in cm.
3. Shape index $= \frac{\text{Diameter}}{\text{Length}} \times 1000$
4. Rind thickness. Fruits were cut cross-wise parallel to the width into two equal parts, and the thickness of the rind was measured in cm.
5. Total soluble solids was determined as a percentage using a hand refractometer.
6. Uniformity and disease resistance were judged visually.

All data were statistically examined by means of analysis of variance. The degree of dominance of the character expressed in the triploid was determined according to POWERS' procedure (1945).

The data on fruit characteristics are shown in Table 1 for the following characters.

Table 1

Average fruit characters of diploids, triploids and their maternal tetraploid Sugar Baby parent

Characters Diploid Cultivars	Weight		Diameter		Length		Shape Index		Rind thickness		Total soluble solids	
	2x	3x	2x	3x	2x	3x	2x	3x	2x	3x	2x	3x
	kg		cm								%	
Shipper	3.664	5.245	18.2	18.4	21.0	21.2	879	873	1.1	1.4	7.8	11.0
Congo	4.750	5.248	18.0	20.0	30.8	24.6	589	818	1.0	1.2	7.7	11.9
Shin Yamato	3.678	3.420	19.8	18.4	20.6	18.4	962	1000	1.1	1.5	8.0	12.7
Giza 1	2.759	3.748	17.0	18.2	18.6	19.8	917	920	0.8	1.2	9.6	11.7
Fairfax	3.463	4.743	13.2	19.0	31.6	24.6	501	770	0.9	1.5	6.9	11.9
X	3.663	4.480	17.6	18.8	24.5	21.7	770	876	1.0	1.4	8.0	11.8
Sugar Baby 4x	3.047		16.8		18.4		910		1.3		10.4	
L.S.D. (0.05%)												
Lots for:	1.626		2.4		3.8		58		0.2		1.6	
Ploidy levels	1.859, 0.727		1.9, 1.1		2.9, 1.7		45, 26		0.2, 0.1		1.2, 0.7	
2x	N.S.		2.4		3.8		58		N.S.		1.6	
3x	N.S.		N.S.		3.8		58		0.2		N.S.	

1. Fruit weight. The results indicate that there were significant differences in fruit weight between 2x, 3x and 4x populations in all crosses except for those which had Shin Yamato and Giza 1 as male parents. The weight of the tetraploid fruit was similar to that of the diploids Shipper and Fairfax, but was heavier than that of Congo. A heavier weight was found in 3x than 4x when Shipper, Congo and Fairfax were used. The triploid fruit was similar in weight to that of the diploids. As to the degree of dominance of this character as shown in the triploids, the data indicate a complete dominance of the heavy weight over light fruit weight in crosses with Shipper, Congo and Fairfax as the large-fruited parents. These results agree with those of KIHARA—NISHIYAMA (1947), KIHARA (1951) and STINO *et al.* (1967). However, the data recorded by MATSUBAYASHI (1954) indicate the production of larger and heavier fruits by the triploids than the diploids. This discrepancy might be attributed to the germplasm of the material studied.

2. Fruit diameter. Significant differences in fruit diameter were found between the populations with different ploidy levels involved in crosses where Congo, Shin Yamato and Fairfax were the male parents. Non-significant differences were found in the other crosses. The diameter of 4x fruit was greater than that of the Fairfax parent, similar to that of Congo, but was less than that of Shin Yamato. The triploid fruit had a similar diameter to that of the tetraploid parent, when Congo and Fairfax were the diploid parents. It was thinner than the latter when Congo was used. A greater diameter in 3x than in 2x was encountered in crosses having Fairfax as the diploid parent. However, a similar diameter was recorded for 3x and 2x fruit when Congo and Shin Yamato were used. The greater fruit diameter of the diploid parent showed a complete dominance over the lesser diameter of the tetraploid parent when Congo and Shin Yamato were the diploid parent. However, heterosis of the large diameter of the tetraploid fruit over the small diameter of the Fairfax diploid was evident. These data are in accordance with those reported by STINO *et al.* (1967) and ABD EL-HAFEZ (1969).

3. Fruit length. Differences in fruit length between diploid, triploid and tetraploid populations were highly significant in two crosses, namely Sugar Baby × Congo and Sugar Baby × Fairfax, but were not significant in other crosses. The tetraploid plant had shorter fruits than the triploid and diploid. Also, the length of the triploid fruit was shorter than that of the diploid. Thus, there was absence of dominance when Congo or Fairfax was the diploid parent. These results agree with the data reported by GREEN (1959) and ABD EL-HAFEZ (1969).

4. Fruit shape index. The data indicate no significant differences in fruit shape index between 2x, 3x and 4x populations when Giza 1 was the male parent, but the differences were highly significant in other crosses. The tetraploid fruit had a greater shape index than the diploid Shipper, Congo or Fairfax, but it was similar to that of Shin Yamato. The triploid fruit was similar to the tetraploid in shape index when Shipper was the diploid parent. The index of 3x fruit was greater than 4x when Shin Yamato was the diploid, but was lower when the diploid parent was Congo or Fairfax. The triploid fruit, in each cross, was similar in shape index to the diploid except when Congo or Fairfax was used, in which case the shape index was greater. Indices with high values denote that the fruit tends to have a round shape, whereas low values indicate a tendency to have an elongated shape. The high index value of fruit shape in the tetraploid parent was completely or partially dominant over the low index of the diploid parent. The dominance was complete in one cross having Shipper as the male parent, and was partial in two crosses having Congo or Fairfax as the paternal parents. Heterosis was found when Shin Yamato was used. These data substantiate those reported by KIHARA (1951), GREEN (1959) and ABD EL-HAFEZ (1969).

5. Rind thickness. There were highly significant differences in rind thickness between populations with different ploidy levels. The thickness of the rind in 4x fruit was greater than that of diploid in all crosses. The triploid and tetraploid fruits had similar rind thicknesses in crosses having Shipper, Congo or Giza 1 as the diploid parent, but the triploid was thicker than the tetraploid when the diploid parent was Shin Yamato or Fairfax. A comparison of the rind thickness between the triploid and its diploid parent revealed that the rind of the 3x fruit was thicker than that of the diploids. The dominance of the thick rind of the tetraploid parent over the thin rind of the diploid parent was complete when Shipper, Congo or Giza 1 was used. Positive heterosis over the tetraploid parent was observed in the case of the diploid Shin Yamato or Fairfax. These data confirmed those obtained by KIHARA (1951), GREEN (1959) and STINO *et al.* (1967).

6. Total soluble solids. Highly significant differences in the total soluble solids existed between diploid, triploid and tetraploid populations. The tetraploid fruit had a higher total soluble solids content than that of diploid in all crosses except when Giza 1 was used, in which case the two populations were similar. The triploid fruit was similar in total soluble solids content to the tetraploid when Shipper, Congo, Giza 1 or Fairfax was the male parent, but it was higher in the case of Shin Yamato. The triploid fruit had a higher total soluble solids content than the diploid in all crosses. Thus, the high total soluble solids content of the tetraploid fruit was completely dominant over the low content of the diploid parent in crosses having Shipper, Congo, Giza 1 or Fairfax as the male parents. Positive heterosis over the tetraploid was evident in the cross between Sugar Baby and Shin Yamato. The results obtained by STINO *et al.* (1967) were in accordance with those of the present investigation, but did not agree with the results obtained by KIHARA (1951), MATSUBAYASHI (1954) and GREEN (1959), who found no difference in total soluble solids between triploid and diploid fruits. This discrepancy might be attributed to the nature of the material studied.

7. Rind colour. One type of cross was made between parents with dark green and light green, striped rind. Two crosses were used as follows:

1. Sugar Baby × Shin Yamato
2. Sugar Baby × Fairfax

The tetraploid female parent, Sugar Baby, was characterized by a dark green rind, whereas the fruits of the diploid parents Shin Yamato and Fairfax were light green with dark green stripes. The triploid plant of this type produces fruit with a more intensive rind colour than the male parent, nearer to that of the female parent. Obviously, dark green was incompletely dominant (partial dominance) to light green striped. However, when two alleles for dark green interact with one allele for light green striped, there was a gene dosage effect giving a new phenotype in the 3x. The gene symbol G — g^s was suggested by WALL (1960). The factorial analysis of the parents and F_1 would appear as follows:

P_1 (4x)	GGGG	dark green
P_2 (2x)	$g^s\ g^s$	light green, striped
F_1 (3x)	G G g^s	less-dark green, striped

Therefore, it would be easy to distinguish between 3x and 4x plants by incorporating a marker gene for rind colour in the triploid that would be transmitted from the male parent. The present data are in agreement with those reported by KIHARA (1951), SHIMOTSUMA (1957), GREEN (1959), WALL (1960) and ABD EL-HAFEZ (1969).

8. Uniformity of fruits and disease resistance. It was important to note that all the triploid fruits were uniform in shape without malformation, with good quality, and free from anthracnose and blossom-end rot. The plants were also resistant to wilting. These remarks must be studied in detail to prove these facts in other experiments.

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Prepared at the Department of Horticulture, Faculty of Agriculture, Cairo University, Cairo

A. A. ABD EL-HAFEZ

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PHYSIOLOGY OF SEED DORMANCY IN SUNFLOWER (HELIANTHUS ANNUUS L.)

Most of the studies on seed dormancy have revealed that inhibitors are the basic cause of seed dormancy and promotors help in releasing dormancy (HOMBURG 1949, LUCKWILL 1952, SRIVASTAVA 1977). Until the middle sixties only inhibitors and gibberellins were positively implicated in the control of seed germination and dormancy (VEGIS 1964, LANG 1970, KHAN 1971, WAREING—SAUNDERS 1971). The role of cytokinin in reversing the effect of natural inhibitors and thus inducing germination was demonstrated in lettuce seeds (KHAN 1967, 1968, 1969). The role of ethylene in breaking the dormancy in subterranean clover was demonstrated by ESASHI—LEOPOLD (1969), in peanut seeds by KETRING—MORGAN (1969) and in cocklebur seeds by KATOSH—ESASHI (1975a, b), but no specific hypothesis on its functional aspect has been developed.

In the present study seeds of sunflower having early short-term dormancy and responsive to ethylene, were selected to develop a working model for ethylene and its involvement in the regulation of seed dormancy.

Germination tests: Seeds were surface-disinfected for 2 min with 0.1% mercuric chloride and also with antibiotic solution (2 μg each penicillin + streptomycin in 1 ml distilled water), rinsed three times with sterile distilled water, and germinated in sterilized petri dishes lined with blotting paper, having distilled water as the germinating media. Germination was done in the dark and only those seeds which had attained a radicle length of 2 mm and produced normal seedlings were counted as germinated. All the experiments were run in three replicates.

Electrophoretic proteins

Polyacrylamide gel of 8% concentration was prepared according to the slightly modified method of LUND (1965). Protein samples were applied with a syringe in the slits prepared on the gel by pulling out the bridge inserted in the gel during gel polymerization. A very small amount (0.001%) of bromophenol blue was applied on each slit. Protein bands were separated on the gel by passing a constant electric current of 30 mÅ and 250 V through an electrophoretic tray filled with boric acid-borate buffer (pH 8) as electrode buffer. After about two hours, when the dye reached the other end of the tray, the electricity was switched off and the gel was removed from the tray. Horizontal slicing of the gel was done with a very fine silk thread.

The gel so obtained was fixed in 7.5% trichloro-acetic acid and stained for 15 minutes with a mixture of Amido-Schwartze 10 B and brilliant 100 massive blue dissolved in a solvent mixture of acetic acid : methanol : water (1 : 4 : 5). Destaining of the gel was done with repeated washing of the gel with 7% acetic acid for three days after which blue bands become clearly visible on the transparent background.

Thin layer chromatography (TLC) for the separation of lipid components: Total lipids were extracted from the samples in a chloroform : methanol mixture (2 : 1 v/v) after the method of FLOCH *et al.* (1957). Different components of lipids were separated on TLC plates coated with a thin layer (250 μ) of slurry prepared by thoroughly mixing silica gel G and H_2O (1 : 2 w/v) after the method of DEVIDEK—PROCHAZKA (1961). TLC plates were air dried and activated in an oven at 110 °C for 45 minutes, then cooled to room temperature in a desiccator. Ten microlitres of lipid sample (1% solution in chloroform) was dripped with the help of a capillary tube 3 cm above the lower edge of the TLC plate. For the separation of non-polar lipids the solvent system petroleum ether : ethylether : acetic acid (80 : 20 : 1 v/v) was used in a single dimensional system and for polar lipids the solvents used in the two dimensional run were I) chloroform : methanol : H_2O (65 : 25 : 4 v/v) and II) chloroform : methanol : 7 N ammonia (65 : 25 : 4 v/v). TLC plates were developed by ascending chromatography up to 15 cm from the point where the spots were made.

Non-polar lipids were quantitatively analysed after the method of FEWSTER *et al.* (1969). The developed chromatoplates were sprayed with cupric acetate phosphoric acid reagent and charred at 150 °C for 30 min. The intensity of the charred spots was measured densitometrically. The peak area representing integrated optical density values was measured with a planimeter.

The polar lipids on the TLC plates were located by exposure to iodine vapours, eluted in chloroform : methanol (1 : 1 v/v) and shaken with water. Polar lipids dissolved in chloroform settle in the lower layer, which was removed and estimated for their quantity following the method of RAHEJA *et al.* (1975). The colour intensity was read at 710 nm and compared on a standard curve for quantitative estimation.

Gibberellic acid (10 ppm), kinetin (20 ppm) and ethrel (250 ppm) were used, based on their maximum response curve, to study their effect in breaking seed dormancy. The surface sterilized seeds were soaked in these solutions for 18 hrs and thoroughly washed with distilled water before putting them for germination in sterilized Petri dishes. The germination counts were made after 120 hrs of germination.

Cytokinin bioassay

The cytokinin was extracted in 95% ethanol and left over night. Ethyl acetate was added to the filtrate in acidic pH and a precipitate was obtained by adding a few crystals of silver nitrate to it. The precipitate was treated with diethylether and filtered. The residue was dissolved in absolute alcohol and concentrated at room temperature. The cytokinin was determined in the plant extract by a modified *Amaranthus* betacyanin bioassay test following the method of BIDDINGTON—THOMAS (1973). The quantitative estimation of Betacyanin was done by calculating the difference between the optical densities at 542 nm and 620 nm (BIGOT 1968). The quantity of cytokinin was calculated by using a standard curve and was expressed in μg/g fresh weight.

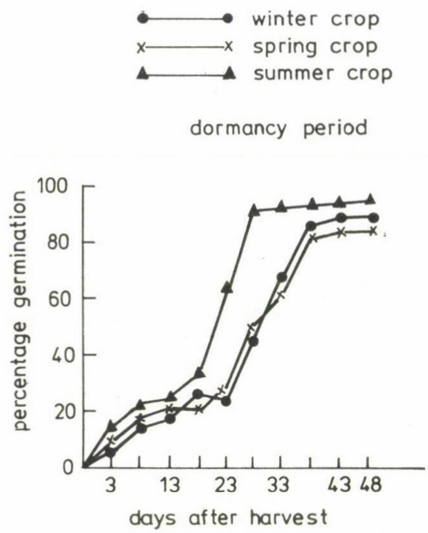

Fig. 1. Duration of dormancy in sunflower seeds obtained from crops raised in the three different seasons

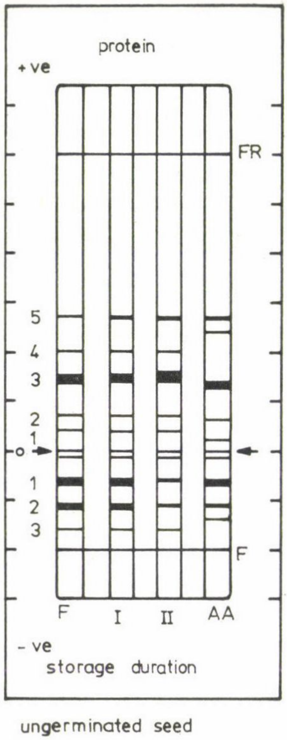

Fig. 2. Electrophoretic separation of protein bands in freshly harvested, one and two-year-old and non-viable accelerated aged seeds of sunflower

Detection of ethylene by gas layer chromatography (GLC)

Surface sterilized seeds were placed in 250 ml sterilized conical flasks specially designed for this work (SRIVASTAVA *et al.* 1979). The flasks were incubated at a fixed temperature of 30 °C. Seeds subjected to various treatments, as given in Table 3, were incubated for 24, 48 and 72 hours before recording the GLC reading. Ethylene evolution was detected by AIMIL gas layer chromatography, using a flame ionisation detector with the carrier gas nitrogen at 171.44 kg/m pressure. Hydrogen was used as fuel gas. The retention time for ethylene was 2.1 minutes. The detection limit of the gas chromatography was 0.1 μl of ethylene gas injected. The gas volume were quantified by idealising the peaks as bilateral triangles and comparing with the peaks obtained by injecting the standard ethylene samples.

Sunflower seeds collected from the crop in winter, spring and summer, all gave different values with respect to the duration of dormancy and overall germination. The dormancy period in seed of the summer crop was relatively shorter than those of spring and winter. Dormancy release during storage required about 33 days for seeds of the summer crop and about 48 days for the winter and spring crops for maximum germination (Fig. 1). Overall germination after the release from dormancy was maximum in the seeds of the summer crop, followed by the winter and the spring crop.

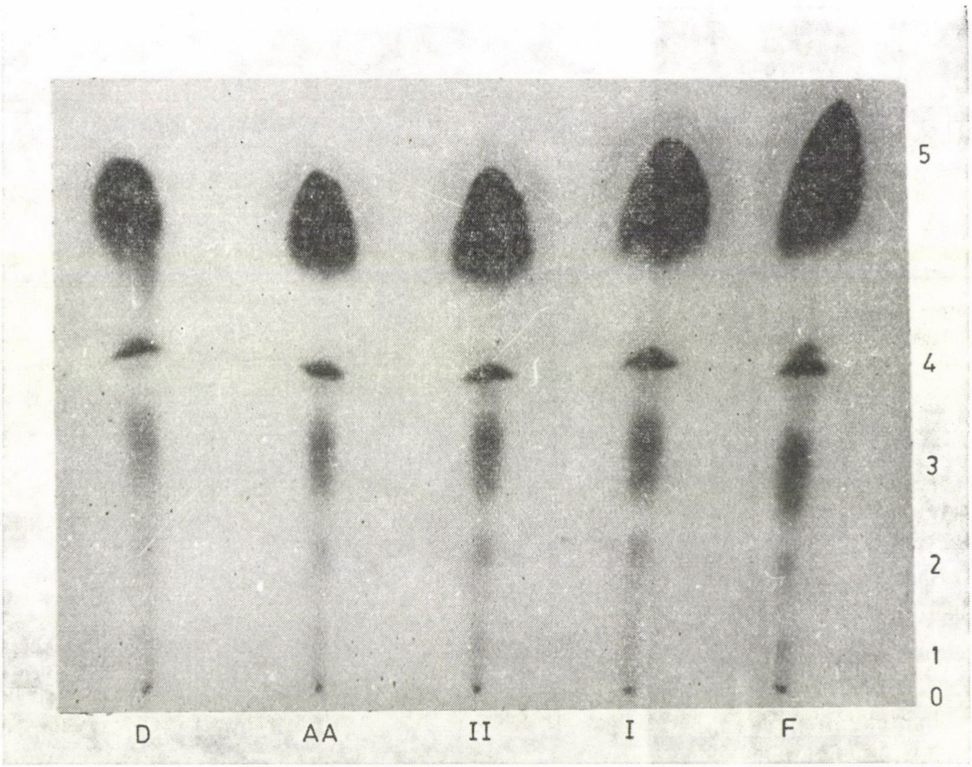

Fig. 3. Non-polar lipid fractions in freshly harvested dormant (D), accelerated aged non-viable (AA), two-year-old (II), one-year-old (I) and four-month-old non-dormant seeds of sunflower. (0. Origin, 1. Monoglycerides, 2. Diglycerides, 3. Sterol, 4. Free fatty acids, 5. Triglycerides)

Attempts were also made to understand the basic differences with regard to some of the biochemical make-up of the dormant, non-dormant and non-viable sunflower seeds. The protein pattern, as revealed by electrophoresis on polyacrylamide gels, was studied in relation to dormant and non-dormant seeds. There were five positive and three negative bands in both the dormant and non-dormant seeds (Fig. 2). The position of the bands in dormant seeds and in 1- and 2-year-old non-dormant seeds were almost identical. The first positive bands in the dormant and non-dormant seeds appeared at RF 0.06, the second at 0.11, the third at 0.25, the fourth at 0.33 and the fifth at RF 0.45. In accelerated aged seeds (non-viable), the first band appeared at RF 0.03, the second at 0.10, the third at 0.21, the fourth at 0.40, and the fifth band at RF 0.45. The negative bands were also identical in all the treatments. There were three bands in all, the first one separating at RF 0.30, the second at 0.55 and the third at RF 0.80. In the accelerated aged seeds the negative bands separate at RF 0.30, 0.55 and 0.70 respectively. From the comparison it can be seen that there was no difference in the protein banding pattern in dormant and in non-dormant seeds, but in accelerated aged (non-viable) seeds, the protein bands were not the same as those of dormant and non-dormant viable seeds.

Table 1

Non-polar lipids in dormant, non-dormant and accelerated aged (non-viable) seeds of sunflower

Treatments	Lipid components (%)				
	Monoglycerides	Diglycerides	Sterol	Free fatty acids	Triglycerides
Four-month-old non-dormant seed	8.4	12.9	18.4	14.5	43.4
One-year-old non-dormant seed	8.6	12.2	16.8	14.5	43.6
Two-year-old non-dormant seed	7.9	12.5	16.2	14.7	43.2
Accelerated aged seed (non-viable)	8.1	10.3	16.4	19.2	40.6
Fresh dormant seed (3 days after harvest)	6.4	7.6	14.7	14.3	39.2

Table 2

Polar lipids in dormant, non-dormant and accelerated aged (non-viable) seeds of sunflower

Treatments	Lipid components (%)					
	Phosphatidic acid	Phosphatidyl choline	Phosphatidyl glycerol	Diphosphotidyl glycerol	Amino phosphatide	Free fatty acids
Four-month-old non-dormant seed	10.1	32.5	5.7	11.3	14.5	18.4
One-year-old non-dormant seed	9.8	31.6	6.2	12.1	14.5	17.6
Two-year-old non-dormant seed	10.7	33.3	5.8	11.3	15.2	17.6
Accelerated aged non-viable seed	11.3	36.0	trace	8.5	12.1	35.3
Fresh dormant seed (3 days after harvest)	10.2	31.3	6.8	12.4	15.3	18.7

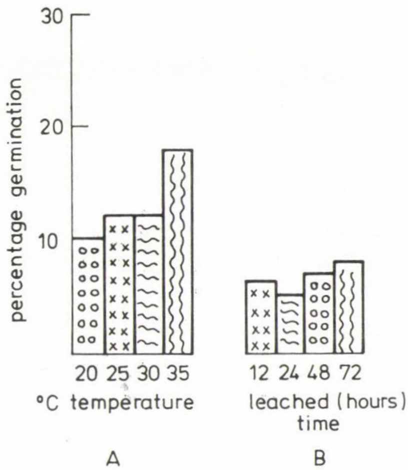

Fig. 4. Effect of different temperature pretreatments (A) and washing of seeds in running tap water for different durations (B) on dormancy release in sunflower seeds

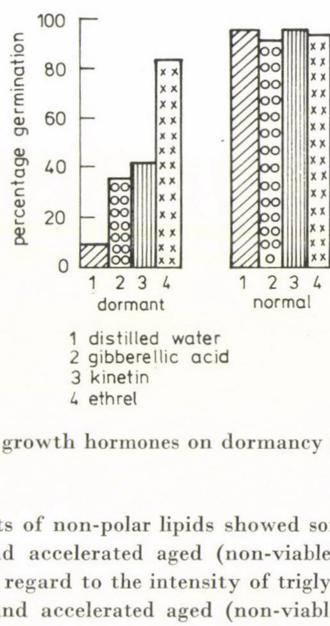

Fig. 5. Effect of different growth hormones on dormancy release in sunflower seeds

The different components of non-polar lipids showed some sharp distinctions between the dormant, non-dormant and accelerated aged (non-viable) seeds. The differences were more obvious particularly with regard to the intensity of triglycerides and diglycerides in the fresh dormant, non-dormant and accelerated aged (non-viable) seeds (Fig. 3). In dormant seeds, the quantity of monoglycerides recorded was 6.4%, diglycerides 7.6%, sterol 14.7%, free fatty acids 14.3% and triglycerides 39.2%. Except for free fatty acids all other components were less than in the non-dormant seeds. In accelerated aged seeds, the quantity of diglycerides and triglycerides was 10.3% and 40.6%, which was less than in non-dormant seeds but more than in dormant ones. Free fatty acid in accelerated aged seeds was the highest as compared to the viable seeds (dormant and non-dormant) (Table 1). Dormant and non-dormant (viable) seeds did not show much difference with regard to their polar lipid fractions. In non-viable seeds phosphatidic acid, phosphatidyl choline and free fatty acids were all higher and phos-

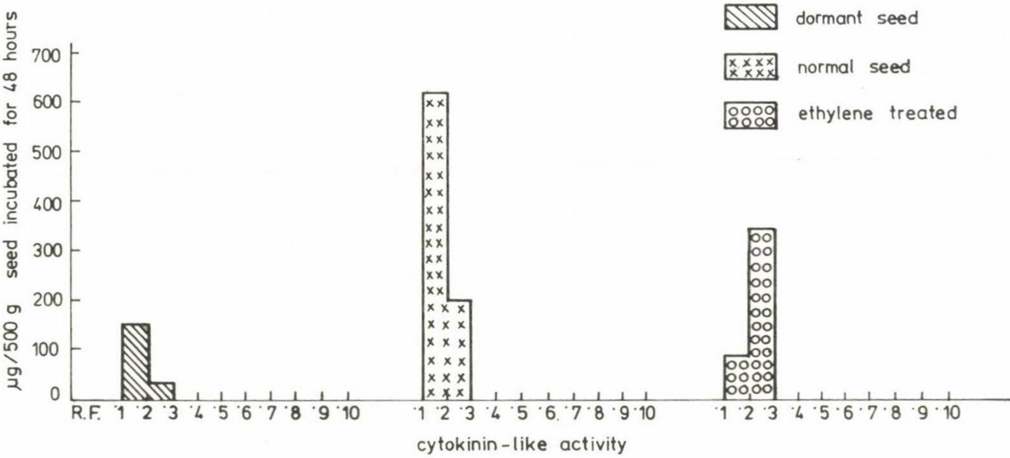

Fig. 6. Bioassay of cytokinin and its activity in dormant, non-dormant and ethylene-treated seeds

phatidyl glycerol, diphosphatidyl glycerol and amino phosphatide were less than in the viable (dormant and non-dormant) seeds (Table 2).

Seeds subjected to 72 hrs of leaching in running tap water, and seeds preconditioned at high or low temperatures showed no improvement in germination (Fig. 4). Treatment with ethrel, kinetin and gibberellic acid helped in releasing early dormancy of sunflower seeds, with a maximum of 80% germination being achieved with ethrel, followed by kinetin and gibberellic acid (Fig. 5). Experiments were planned to correlate the dormancy breaking mechanism and germination response of sunflower seeds with the change in the level of cytokinin. High cytokinin-like activity was noticed in sunflower seeds while germinating, either after completing their physiological maturation or after releasing their dormancy by ethrel treatment. In dormant seeds there was negligible cytokinin activity (Fig. 6). Experiments were also planned to understand the possible involvement of ethrel in releasing sunflower seeds from dormancy. Six combinations of treatments were tried. It was recorded that except in the treatment combination with ethrel, in no other combinations could the evolution of ethylene be detected by gas layer chromatorgraphy (GLC) (Table 3, Fig. 7).

Table 3

Evolution of ethylene from sunflower seeds subjected to different treatment combinations

Seed conditioning	Ethylene evolution (ppm)		
	24 hours	48 hours	72 hours
1 Old seed germinated in distilled water	—	—	—
2 Dormant seed incubated in distilled water	—	—	—
3 Dormant seed treated with ethrel (250 ppm)	2240	++	+++
4 Old seed germinated with combination of 40 ppm kinetin and 40 ppm IAA	—	—	—
5 Old seed germinated in distilled water containing no barium peroxide	—	—	—

\+ Trace

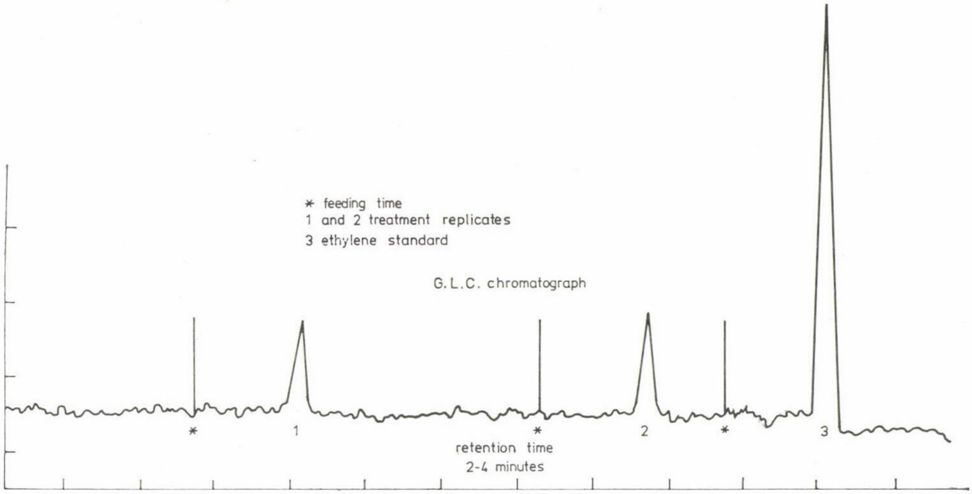

Fig. 7. Gas layer chromatography for the detection of ethylene with two peaks (1 and 2) representing treatment replicates of ethrel-treated seeds and (3) the ethylene standard peak

Seeds of sunflower have a dormancy period of 33 to 48 days (Fig. 1) which is overcome either during storage for a specific period or by exogenous application of ethrel (Fig. 5). It is apparent therefore that during storage seeds change their metabolic activity, which is probably responsible for overcoming post-harvest dormancy. The possibility of a high level of endogenous inhibitor during the dormancy period cannot be ruled out either. During post-harvest storage of seeds the level of endogenous inhibitors might be decreasing, as also indicated by Kozlowski—Gunn (1972). The possibility of an increase in the endogenous level of growth promoter during post-harvest storage as reported by Amen (1963), Vegis (1964) and Wareing—Saunders (1971) also seems to be an important change responsible for breaking dormancy in sunflower seeds. The difference in the length of dormancy in seeds collected during different seasons (Fig. 1) can be attributed to the plant ambient temperature relation during seed development, which determines the inhibitor-promoter ratio. The effect of high temperature during storage or temperature preconditioning of seeds in controlling seed dormancy has been demonstrated by Ketring—Morgan (1970) in peanut seeds.

The almost identical protein banding pattern obtained by gel electrophoresis in dormant as well as non-dormant seeds (Fig. 2) suggests that the difference probably lies only in their activity rather than in their quality and number. Basically, therefore, both dormant and non-dormant seeds have identical potentiality for germination, which does not exist in non-viable seeds. This is also evident from the different set of protein bands as compared to those in viable seeds (Fig. 2). Denaturation of proteins may be one of the causes of inducing non-viability in seeds (Srivastava—Gill 1975, Heeker—Bernherdt 1976). The existence of germination potentiality in dormant seeds of sunflower is further confirmed by the presence of an almost identical composition of polar lipids, though the non-polar lipids were low in dormant as compared to non-dormant ones. The polar lipids were almost identical in both dormant as well as non-dormant seeds. The low quantity of non-polar lipids in the dormant seeds makes it evident that after the release from dormancy these seeds make up the level of non-polar lipids which might indirectly be controlling dormancy. In comparison, the high amount of free fatty acids in accelerated aged (non-viable) seeds suggests its high degree of deterioration, as has also been reported by Christensen (1967) and Koostra—Harrington (1969).

It appears that the dormancy inducing substance(s) in sunflower seeds are water insoluble, as the leaching of seeds with water did not break dormancy in this species (Fig. 4). This therefore appears to be a different case from those where seed dormancy is broken partially or completely by the leaching of inhibitors through rain water or under continuous running water (WAREING 1963, SRIVASTAVA 1977). WAREING (1965) has indicated that the presence of non-leachable inhibitors in the seed pericarp often imposes a high oxygen requirement. This can possibly be explained by the fact that a high oxygen concentration supports the process of oxidation of the inhibitors, by a simple oxygen-coupling reaction, thus inactivating them. This needs further clarification and experimental evidence.

The dormancy release by ethrel in sunflower, giving 82% germination (Fig. 5), has indicated the possibility of the involvement of ethylene at certain stages in seed germination. WARNER—LEOPOLD (1969) have shown that ethrel decomposes linearly with time to yield quantitative amounts of ethylene in an aqueous medium containing plant tissue. The actual mechanism by which ethylene breaks dormancy in seeds is not definitely known. It is reported that a small quantity of ethylene results in increased peroxidase activity (LUIS 1973). It was suggested earlier that inhibitors insoluble in water have a high oxygen requirement for oxidation (WAREING 1965), which is most likely to be substituted by increased peroxidase activity with the application of ethrel (LUIS 1973), simultaneously increasing the permeability of cell membranes. Probably this may be partially true in explaining the ethylene action in breaking seed dormancy. It has also been suggested that ethylene may also break dormancy in seeds by enhancing RNA and protein synthesis (ABELES—HOLM 1966, JARVIS *et al.* 1968, HEEKER—BERNHERDT 1976). Kinetin and gibberellic acid were relatively less efficient in breaking the dormancy of sunflower seeds compared to ethrel, but kinetin was superior to GA_3 and followed ethrel as regards its efficiency in breaking seed dormancy in sunflower (Fig. 5). Cytokinin is also known to break dormancy in seeds by overcoming the ffect of abscisic acid (KHAN 1968, HALLOIN 1976). BROWN—VANSTADEN (1976) reported that the dormancy of *Protea compacta* seeds was not due to endogenous inhibitors but due to the lack of cytokinin and gibberellin-like substances in the seed. Cytokinin is known to trigger IAA uptake and the endogenous IAA level is responsible for the release of ethylene in the tissues (OWENS *et al.* 1971). This suggests that cytokinin acts through auxin in releasing ethylene, which finally participates in breaking the dormancy of sunflower seeds, as has also been pointed out by LAU—YANG (1973). The fact that ethylene is only detected by gas layer chromatography (GLC) in ethrel-treated seeds and not in other cases where dormancy is released (Table 1) suggests that spilled-over ethylene is ineffective in breaking dormancy in sunflower. LIEBERMAN—KUNISHI (1968) have also reported that "spilt-over ethylene" may be of little value as a clue to its mode of action. In treatments with kinetin and gibberellic acid, spilled-over ethylene appears to be so low in concentration that probably it could not be detected by GLC. The effective ethylene appears to form a complex with organic molecules in the system prior to triggering the response to release the sunflower seeds from dormancy. During the post-harvest maturation of seeds there appears to be a slow evolution of ethylene which accumulates in the system in a complex, bound with certain organic molecules and gradually reaches a threshold level which triggers the response to release dormancy in sunflower seeds. As it appears that ethylene regulates dormancy in sunflower seeds, there is no doubt that certain proteins which reversibly inhibit auxin or kinetin-induced ethylene evolution might be present in sunflower seeds, keeping the seeds dormant, as has also been suggested by SAKAI—IMASEKI (1975) in mung bean hypocotyl sections.

The involvement of cytokinin in the ethylene-triggered response of sunflower seeds to release them from dormancy is given further concrete evidence by the fact that there is a much higher level of cytokinin in all the non-dormant seeds than in the dormant seeds of sunflower and this level goes on increasing with the increase in germination duration in non-

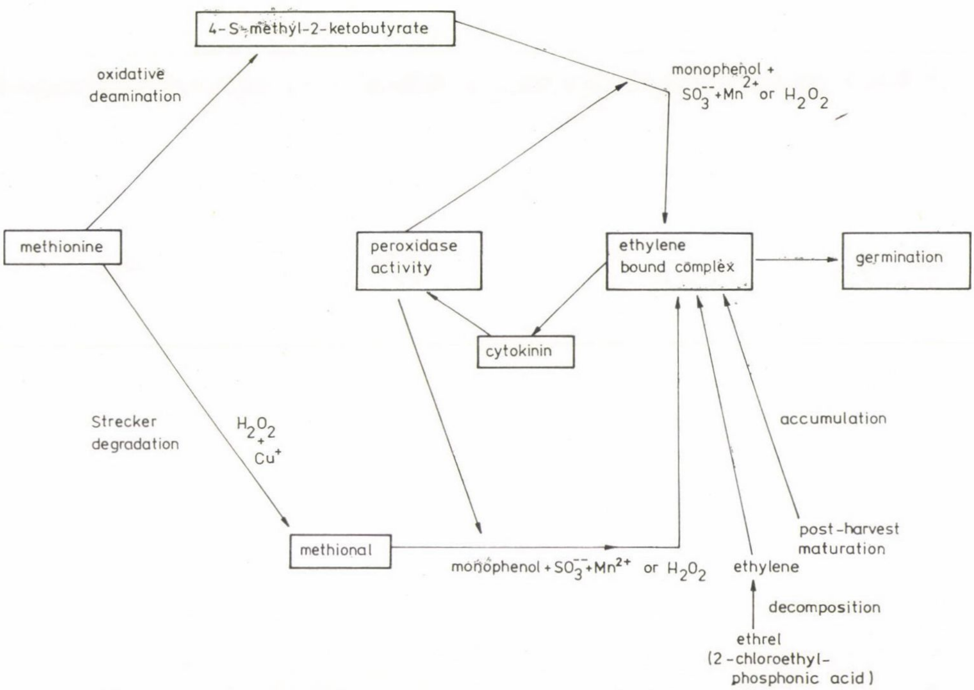

Fig. 8. Model to depict ethylene response to dormancy release in sunflower seeds

dormant seeds (Fig. 6). The hypothesis that cytokinin and ethylene interact to maintain their relative concentration to release the seeds of sunflower from dormancy, receives further support from the observation that there is also a high level of cytokinin in ethrel-treated seeds.

As indicated in the seed dormancy model prepared on the basis of the data presented in this paper (Fig. 8), it appears that cytokinin might trigger the ethylene evolution by an increase in peroxidase activity, which catalyses the conversion of methional, derived either from methionine after Strecker degradation or from the conversion of the α-keto analogue of methionine (4-s-methyl-ketobutyrate), to evolve ethylene (YANG 1967). This ethylene forms a germination factor by binding with certain unknown organic molecules to form a complex which possibly represents the physiologically active component of ethylene responsible for releasing the sunflower seeds from dormancy. Ethylene also appears to trigger the biosynthesis of cytokinin, as evidenced by the data presented in Fig. 6. Thus it appears that ethylene evolution, once it is triggered, will automatically be regulated via the cytokinin-ethylene mediated peroxidation of ethylene precursors in sunflower seeds (Fig. 8). During post harvest maturation, a time-lag is required for the accumulation of the threshold level of ethylene-bound complex, which is immediately accomplished by the exogenous application of ethrel.

However, much evidence is still needed to generalize this model of seed dormancy, specially to those groups of seeds having a positive response to ethylene and kinetin.

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A. K. Srivastava, S. C. Dey

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EVALUATION OF CHEMICAL METHODS FOR THE DETERMINATION OF AVAILABLE PHOSPHORUS IN WATER-LOGGED ALFISOLS. I. PHOSPHATE AVAILABILITY INDICES IN RELATION TO PHOSPHATE FRACTIONS

Phosphorus exhibits complex behaviour regarding its availability to crops in Alfisols in Himachal Pradesh. It is a common observation that wheat crops grown on these soils suffer from extreme phosphorus deficiency while paddy may or may not show a deficiency, although the commonly used Olsen's soil test reveals a small amount of available phosphorus on an air dry basis for both the crops.

OLSEN—FRIED (1957) have emphasized the importance of the forms and solubilities of soil inorganic phosphorus for phosphorus availability in soils. In recent years a number of workers have used phosphate fractionation studies for the purpose of assessing the forms of phosphorus contributing to plant phosphate uptake (AL-ABBAS—BARBER 1964) and to extraction by chemical methods (CHANG—CHU 1961, CHANG—JUO 1963). Such studies have been helpful in devising better methods of soil phosphate evaluation and also in understanding the phosphate release under varying soil environmental and crop conditions. Studies of this nature, however, have been employed by and large on air dry soils. The extrapolation of the results of these studies to water-logged soils is limited in scope, as the physico-chemical regime of water-logged soils is quite different from that of upland soils, which may be assessed on the basis of air dry soils.

In the present investigation an attempt has been made to study the relationship between phosphate availability indices and phosphate fractions in both air dry and water-logged paddy soils in order to devise a suitable method for assessing the phosphate availability in water-logged soils on the basis of air dry soil samples.

Soils

The state of Himachal Pradesh is located between latitudes 30° and 33°N and between longitudes 75° and 79°E in the extreme northwest of India. The Alfisols occupy about 25% of the total cultivated area of the state. Rice is the most important crop grown on these soils. For the purpose of the present study twelve soil samples were taken from the upper

Table 1

Some important physico-chemical characteristics of soils

Soil	pH	Organic matter	$CaCO_3$	R_2O_3	Sand	Silt	Clay
		%					
Bhadiarkhar	5.4	1.36	0.25	25.2	4.3	62.9	32.2
College farm	5.4	1.21	0.25	12.4	3.1	71.0	25.4
Sidhbari	5.5	1.93	0.25	8.1	7.5	72.8	19.5
Kalolidevi	6.7	1.45	1.00	9.0	8.0	73.7	17.8
Panarsa	6.8	1.67	1.00	14.3	10.5	71.0	18.0
Palchhan	6.5	1.05	1.00	16.4	12.3	70.8	16.6
Chovine	6.8	1.52	0.15	14.5	9.5	72.8	17.1
Jadrangal	6.0	1.67	1.00	17.1	10.2	73.0	90.9
Janjahli	6.0	0.74	0.50	18.0	6.4	73.1	20.0
Jhahu	6.5	0.53	1.00	23.8	10.7	68.0	20.4
Rehlu	6.7	1.26	0.75	7.9	13.2	72.0	14.3
Bhanatta	6.8	1.36	0.75	23.6	5.2	64.2	29.7

23 cm of traditionally rice growing areas falling in the Alfisols belt. The important physico-chemical characteristics of these soils are given in Table 1.

The soils were acidic to neutral in reaction, while the organic matter varied between 0.53 to 1.93% and $CaCO_3$ between 0.15 to 1.00%. The soils owe their origin to phyllites, shists, gneisses, granites, shales and sand stones under a wet temperate type of climate and have been classified as Alfisols by VERMA (1973), with a colour varying from light to dark grey. The texture of these soils varied from fine sandy loam, through silt loam to silty clay loam. The soil samples were air dried and crushed to pass through a 2 mm sieve.

Analytical methods

Depending on the extraction and fractionation methods to be followed, duplicate soil samples were weighed into extraction bottles. A measured amount of distilled water was added to water-log the soil about 4 cm above its surface. The bottles were stoppered with corks in which tiny holes were made for gas exchange and kept in the laboratory at room temperature for ten weeks. Air dry soils were also weighed into similar extraction bottles and kept in the laboratory. After a ten-week interval, both the air dry and water-logged soil samples were extracted by the methods used by OLSEN *et al.* (1954), BRAY—KURTZ (1945), TRUOG (1930), ANONYMOUS (1953), PEECH—ENGLISH (1944) and MORGAN (1941). The soil phosphate fractionation studies were carried out according to the method suggested by PETERSON—COREY (1966).

The matrix of correlation coefficients relating phosphate availability indices to the forms of soil phosphorus and stepwise regression for the relationship between phosphate availability indices and phosphate fractions were worked out both for air dry and water-logged soil with the help of a computer.

Transformation of phosphorus

The distribution of Al-P, Fe-P, Ca-P and Red-P in dry soils and after ten weeks of water-logging are given in Table 2. In all twelve soils, reductant soluble phosphate constituted the dominant phosphate fraction. As regards the abundance of other phosphate fractions, in seven soils Al-P was the second dominant phosphate fraction followed by Fe-P, while in five soils Fe-P was the second dominant phosphate fraction followed by Ca-P. The average relative abundance of inorganic phosphate in Al-P, Fe-P, Ca-P and Red-P fractions in all the soils was 1.00, 1.05, 0.91 and 2.64 respectively. The soils in the present investigation have developed under intense rainfall (2768.5 mm) accompanied by an acid environment. This seems to be an important factor in the high proportion of reductant soluble phosphate in these soils. Furthermore, these soils have been cultivated with paddy and wheat in rotation for many decades. During the paddy growing season the soils are exposed to extreme reducing conditions while during the wheat growing season they undergo alternate wetting and drying due to irrigation. This type of agricultural practice also seems responsible for the phosphate in the soil matrix giving rise to a proportionately high amount of reductant soluble phosphate.

The water-logging of the soils for ten weeks increased the amount of all the inorganic phosphate fractions considered in this study. Of the four fractions, the maximum increase

Table 2

Inorganic phosphate fractions (ppm) in air dry and water-logged soils

Soils	Air dry				Water-logged			
	Al-P	Fe-P	Ca-P	Red-P	Al-P	Fe-P	Ca-P	Red-P
Bhadiarkhar	40.0	37.2	25.7	95.0	48.4	87.5	25.0	117.6
College farm	37.2	30.0	18.4	90.2	40.2	40.0	20.2	112.9
Sidhbari	35.1	34.8	25.3	88.1	41.7	57.5	28.0	102.0
Kalolidevi	19.3	27.4	21.2	58.2	22.2	34.7	27.5	70.0
Panarsa	19.4	26.7	25.0	82.5	43.6	45.0	24.8	95.5
Palchhan	38.2	30.0	27.0	68.7	41.3	78.3	27.5	90.2
Chovine	34.4	33.9	25.5	75.4	37.4	72.5	26.2	96.0
Jadrangal	38.3	31.4	19.5	82.2	40.0	41.2	20.0	93.1
Janjahli	35.2	33.5	40.3	85.7	40.9	70.9	45.0	100.5
Jhahu	20.2	29.1	35.7	62.6	23.2	38.4	26.5	85.2
Rehlu	15.7	31.2	38.2	71.5	20.4	39.0	37.2	88.4
Bhanatta	20.6	28.5	21.7	75.3	25.7	32.5	23.8	92.0
Mean	29.5	31.1	26.9	78.0	35.3	53.1	27.6	95.3

was observed in Fe-P which averaged 70.7%. The Al-P increased by 19.7%, Red-P by 22.1% and Ca-P by 2.6%. The ratios of Al-P, Fe-P, Ca-P and Red-P after water-logging were 1.00, 1.50, 0.78 and 2.70 respectively, as against 1.00, 1.05, 0.91 and 2.64 for dry soils. MAHAPATRA—PATRICK (1971) studied the effect of water-logging on the phosphate availability of some low-land rice soils in Louisiana. Their data also show an increase in the total of inorganic phosphate fractions. But they reported a reduction in the reductant soluble Fe-P after water-logging. The increase in the Al-P fractions of inorganic phosphate in soils after water-logging has been attributed in Al-P to hydrolysis (SHAPIRO 1958), in Fe-P to the transformation of ferric phosphate to the more soluble ferrous phosphate (BASAK—BHATTACHARYA 1962, PATRICK 1964, KHAN—MANDAL 1973), and in Ca-P to the conversion of insoluble tricalcium phosphate to the more soluble mono and dicalcium phosphates (MANDAL 1964). The increase in Red-P in soils is not of common occurrence, as water-logging generally solubilizes coatings of hydrated ferric and iron oxides along with soil particles, resulting in a decrease in its amount. But this may occur more frequently where solubilized phosphate is simultaneously removed by plants or by some other mechanism.

Amount of phosphorus extracted

The values of phosphate determined by seven commonly used extractants are given in Table 3. The Morgan and Truog extractants were least effective in extracting available phosphate in air dry soils. Bray P_2 extracted the highest amount of phosphate, followed by

Table 3

Phosphate availability indices (ppm) by different chemical extractants in air dry and water-logged soils

Soils	Air dry							Water-logged						
	Olsen	Bray P_1	Bray P_2	Truog	North Carolina	Peech	Morgan	Olsen	Bray P_1	Bray P_2	Truog	North Carolina	Peech	Morgan
Bhadiar-khar	32.0	61.2	70.0	12.0	15.0	28.0	4.5	33.7	67.0	70.0	21.2	50.5	46.0	4.7
College farm	4.0	2.5	6.0	1.0	2.2	2.0	0.5	10.0	5.0	7.5	2.5	6.5	4.0	1.2
Sidhbari	8.0	22.5	38.7	4.1	29.0	22.1	1.0	8.7	22.5	50.0	17.5	75.5	37.0	1.9
Kiloli-devi	5.0	8.1	13.7	1.0	11.0	6.0	0.5	8.7	10.0	18.7	12.5	41.0	18.0	1.4
Panarsa	7.1	8.1	16.2	1.0	9.2	4.0	0.9	12.5	14.4	43.7	10.0	31.5	14.0	1.4
Palchhan	12.5	60.0	68.0	2.2	23.5	16.0	0.9	15.0	61.7	90.0	7.5	67.0	27.0	1.4
Chovine	9.0	17.5	31.2	1.0	17.5	20.3	1.5	12.5	27.5	46.2	12.5	30.0	27.0	3.1
Jadran-gal	4.0	8.1	7.5	1.0	8.0	8.4	0.5	8.7	8.1	18.7	2.5	26.5	11.0	0.6
Janjahli	20.0	56.2	89.0	6.1	41.0	36.1	5.0	20.0	59.0	90.0	10.0	82.5	46.0	4.4
Jhahu	6.5	8.7	12.5	1.0	10.1	8.0	1.7	10.0	12.5	18.7	10.0	25.0	14.0	1.6
Rehlu	10.0	8.1	20.0	2.0	11.5	16.0	1.5	10.0	10.2	25.0	10.2	36.5	18.0	2.3
Bhanatta	4.0	8.7	31.2	1.0	7.5	18.3	0.9	6.2	12.5	31.2	9.5	52.0	20.0	0.9
Mean	10.2	22.5	35.3	2.8	15.4	15.4	1.6	13.0	25.8	48.3	12.2	43.7	23.5	2.1

Table 4

Matrix of correlation coefficients relating phosphate availability indices to the fractions of soil phosphate

	Air dry				Water-logged			
	Al-P	Fe-P	Ca-P	Red-P	Al-P	Fe-P	Ca-P	Red-P
Fe-P	0.668*				0.751**			
Ca-P	−0.261	0.191			−0.089	0.244		
Red-P	0.623*	0.610*	−0.172		0.736**	0.509	−0.124	
Olsen P	0.424	0.709**	0.367	0.455	0.578*	0.797**	0.216	0.584*
Bray P_1P	0.579*	0.758**	0.325	0.297	0.641*	0.919**	0.395	0.394
Bray P_2P	0.588*	0.797**	0.390	0.235	0.577*	0.954**	0.552	0.287
Truog P	0.457	0.765**	0.234	0.586	0.163	0.93	0.206	0.189
North Carolina P	0.367	0.508	0.543	0.180	0.323	0.508	0.602*	0.032
Peech P	0.371	0.748**	0.506	0.363	0.542	0.789**	0.548	0.356
Morgan P	0.297	0.635*	0.589*	0.411	0.442	0.742**	0.577*	0.470
	Olsen	Bray P_1	Bray P_2	Truog	Olsen	Bray P_1	Bray P_2	Truog
Bray P_1	0.844**				0.827**			
Bray P_2	0.741**	0.965**			0.639*	0.934**		
Truog	0.949**	0.748**	0.632*		0.552	0.451	0.391	
North Carolina	0.474	0.700*	0.783**	0.423	0.299	0.663*	0.797**	0.470
Peech	0.732**	0.745**	0.000**	0.706*	0.704*	0.831**	0.820**	0.735**
Morgan	0.883**	0.722**	0.682*	0.830**	0.832**	0.728**	0.620*	0.630*
		North Carolina	Peech		North Carolina	Peech		
Peech		0.802**			0.819**			
Morgan		0.598*	0.815**		0.420	0.828**		

** Significant at 1% level of significance.
 * Significant at 5% level of significance.

Table 5

Stepwise regression data for the relationship between

Y	Air dry				
	Step No.	Variable on which Y is regressed	R^2	R^2	F value
1	2	3	4	5	6
	1	Fe-P	0.5026**		10.11
Olsen	2	Fe-P, Al-P	0.5583*	0.0556	5.69
	3	Fe-P, Al-P, Red-P	0.5741	0.0157	3.59
	4	Fe-P, Al-P, Red-P, Ca-P	0.5760	0.0019	2.38
	1	Fe-P	0.5558**		7.55
Bray P_1	2	Fe-P, Al-P	0.5787*	0.0229	6.10
	3	Fe-P, Al-P, Red-P	0.5844	0.0057	3.75
	4	Fe-P, Al-P, Red-P, Ca-P	0.5859	0.0015	2.48
	1	Fe-P	0.6241**		6.40
Bray P_2	2	Fe-P, Al-P	0.6958*	0.0717	4.96
	3	Fe-P, Al-P, Red-P	0.7011	0.0053	3.02
	4	Fe-P, Al-P, Red-P, Ca-P	0.7015	0.0004	1.99
	1	Fe-P	0.5854**		14.12
Truog	2	Fe-P, Al-P	0.6079*	0.0225	6.98
	3	Fe-P, Al-P, Red-P	0.6291*	0.0212	4.52
	4	Fe-P, Al-P, Red-P, Ca-P	0.6353	0.0062	3.05
	1	Ca-P	0.2952*		7.15
North	2	Ca-P, Al-P	0.5732*	0.2780	6.04
Carolina	3	Ca-P, Al-P, Red-P	0.5761	0.0029	3.62
	4	Ca-P, Al-P, Red-P, Fe-P	0.5780	0.0019	2.40
	1	Fe-P	0.5586**		12.20
Peech	2	Fe-P, Ca-P	0.6967**	0.1381	10.34
	3	Fe-P, Ca-P, Al-P	0.6975*	0.0008	6.15
	4	Fe-P, Ca-P, Al-P, Red-P	0.6978	0.0003	4.04
	1	Fe-P	0.4037**		8.85
Morgan	2	Fe-P, Ca-P	0.6303*	0.2266	7.67
	3	Fe-P, Ca-P, Red-P	0.6796*	0.0493	5.66
	4	Fe-P, Ca-P, Red-P, Al-P	0.6820	0.0024	3.75

** Significant at 1% level of significance.
* Significant at 5% level of significance.

phosphate availability indices, Y, and phosphate fractions

Water-logged				
Step No.	Variable on which Y is regressed	R^2	R^2	F value
7	8	9	10	11
1	Fe-P	0.6345**		17.36
2	Fe-P, Al-P	0.6776**	0.0431	9.46
3	Fe-P, Al-P, Red-P	0.7197*	0.0421	6.85
4	Fe-P, Al-P, Red-P, Ca-P	0.7202*	0.0105	4.50
1	Fe-P	0.8456**		54.75
2	Fe-P, Al-P	0.8754**	0.0308	31.90
3	Fe-P, Al-P, Red-P	0.8777**	0.0013	19.13
4	Fe-P, Al-P, Red-P, Ca-P	0.8782**	0.0005	12.62
1	Fe-P	0.9101**		22.35
2	Fe-P, Al-P	0.9809**	0.0708	20.62
3	Fe-P, Al-P, Red-P	0.9888**	0.0079	12.86
4	Fe-P, Al-P, Red-P, Ca-P	0.9898**	0.0010	8.46
1	Fe-P	0.2431		3.21
2	Fe-P, Al-P	0.3423	0.0992	2.34
3	Fe-P, Al-P, Red-P	0.3671	0.0248	1.55
4	Fe-P, Al-P, Red-P, Ca-P	0.3690	0.0019	1.02
1	Ca-P	0.3692*		5.70
2	Ca-P, Al-P	0.5058*	0.1429	4.61
3	Ca-P, Al-P, Red-P	0.5683*	0.0625	3.51
4	Ca-P, Al-P, Red-P, Fe-P	0.5783	0.0100	2.40
1	Fe-P	0.6228**		15.56
2	Fe-P, Ca-P	0.7568**	0.1340	14.00
3	Fe-P, Ca-P, Al-P	0.7644**	0.0076	8.65
4	Fe-P, Ca-P, Al-P, Red-P	0.7645*	0.0001	5.68
1	Fe-P	0.5508**		13.49
2	Fe-P, Ca-P	0.7174**	0.1666	11.42
3	Fe-P, Ca-P, Red-P	0.7747**	0.0573	9.17
4	Fe-P, Ca-P, Red-P, Al-P	0.8035*	0.0288	7.16

Bray P_1. The North Carolina and Peech methods gave higher values of extracted phosphate than Olsen's phosphate. The mean values of phosphate extracted by all the methods from water-logged soils were higher than those extracted from air dry soils. Similar results have also been reported by PATRICK (1964), EKPETE—CORNFIELD (1966) and EKPETE (1976). The higher mean values of extractable soil phosphate may be attributed to the mobilization of soil phosphate under water-logged conditions due to a decrease in the redox-potential of the soils. The maximum increase in the value of extracted phosphate due to water-logging was observed in Truog and North Carolina phosphate and the minimum in Bray P_1. The percentage increase in phosphate due to water-logging in the case of different extractants was 27.4, 14.6, 36.8, 335.7, 183.7, 52.6 and 23.8 for Olsen, Bray P_1, Bray P_2, Truog, North Carolina, Peech and Morgan respectively.

Relationship between inorganic phosphate fractions and extractable phosphorus

The values of various inorganic phosphate fractions were related to the phosphate extracted by different extractants by simple correlations both for air dry and water-logged toils (Table 4). A study of the 'r' values indicates that Fe-P fractions constituted the most important phosphate fraction from the point of view of phosphate availability, as this showed significant positive correlations with the phosphate extracted by six extractants out of seven under air dry conditions and five under water-logged conditions. Contrary to Fe-P, the Al-P, Ca-P and Red-P were correlated with only one extractant under air dry conditions and with one or two under water-logged conditions. The value of 'r' between Fe-P and extractable phosphates in general was higher under water-logged conditions than air dry conditions. Besides Fe-P, Bray P_1 and Bray P_2 extracted Al-P under both water-logged and air dry conditions. Under water-logged conditions Olsen's phosphate extracted phosphate from Al-P and Red-P as well as from Fe-P. Red-P was also correlated with Truog's phosphate under air dry conditions. Calcium phosphate contributed to Morgan's phosphate under air dry conditions and to North Carolina and Morgan's phosphate under water-logged conditions. It is pertinent to indicate that of the various extractants, Bray P_1, Bray P_2 and Morgan's extractants removed phosphate from the same fractions under both water-logged and air dry conditions.

The linear stepwise regressions to assess the relative contribution of various inorganic phosphate fractions to extractable phosphate were computed and the equations obtained are given in Table 5. In this table the steps are arranged in accordance with their relative importance towards the dependent variables.

From the order of the relative importance of the independent variables it is evident that the most important variable contributing to the total variation in the regression of Olsen, Bray P_1, Bray P_2, Truog, Peech and Morgan's phosphate was Fe-P in both air dry and water-logged conditions. The R^2 values indicate that about 63, 84, 91, 24, 62 and 55% of the total variation in Olsen, Bray P_1, Bray P_2, Truog, Peech and Morgan's phosphate, respectively, was attributable to Fe-P in water-logged soils and 50, 55, 62, 58, 56 and 40% in air dry soils. The extraction of Fe-P by these extractants was apparently in decreasing order of efficiency: Bray P_2 > Bray P_1 > Olsen > Peech > Morgan > Truog in water-logged soils and Bray P_2 > Truog > Peech > Bray P_1 > Olsen > Morgan in air dry soils. Contrary to this, the variation in the regression of North Carolina phosphate was mainly due to Ca-P.

The second stage of the stepwise regression analysis indicated that Al-P was the second most important inorganic phosphate fraction contributing to the total variation in five out of seven phosphate extractants in air dry soils and four in water-logged soils. The four extractants which bore a significant positive correlation with Al-P under both situations were Olsen, Bray P_1, Bray P_2 and North Carolina. The relative efficiency of these extractants to solubilize Al-P was in the decreasing order: North Carolina > Bray P_2 > Olsen > Bray P_1 for both air dry and water-logged soils. A study of the R^2 values, however, indicates that the contribution of Al-P towards the extractable phosphate by the Bray P_2, Bray P_1 and Olsen methods was small. As regards the total variation in the regression of Peech and Morgan's phosphate, Ca-P was the second most important variable both in air dry and water-logged soils.

These observations suggest that Fe-P was the most important phosphate fraction contributing to extractable phosphate with the Bray P_2, Bray P_1, Olsen and Truog extractants, Ca-P and Al-P for the North Carolina extractant and Fe-P and Ca-P for the Peech and Morgan extractants in both air dry and water-logged conditions.

As regards the suitability of the soil test method for water-logged soils, all the methods which extract phosphate from the same fractions under air dry and water-logged conditions may prove reliable. The stepwise correlation studies clearly indicate that such methods for the present group of soils are Bray P_2, Bray P_1, Olsen, North Carolina, Peech and Morgan. However, their suitability needs to be judged in relation to plant growth parameters.

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Prepared at the Department of Soil Science and Water Management, Himachal Pradesh Agricultural University, Palampur

T. S. Verma, B. R. Tripathi

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RICE HULLS IN THE NUTRITION OF RUMINANTS
I. FATE OF SILICA IN LAMBS FED ON RICE HULLS

The use of straw has increased recently in the feeding of ruminants. Where the climate is adequate for rice production, the large amounts of rice hulls can be used in sheep and cattle nutrition, especially in countries with an insufficient feedstuff supply. The rice production of the world is about 59 million tons per year (ANONYMOUS 1974). The rice hulls used in the present experiments were prepared by the method used in the European rice industry. Rice hulls (RH) are removed from the grain at the mill and represent approximately 20% of the unmilled rice, so they are an important by-product of the rice industry. Some critical nutritional studies on RH as a component of ruminant diets have been reported by CHOUNG—MCMANUS (1976). One of the problems in feeding RH is its high silica content. RH contains 20—22% silica (TILLMAN *et al.* 1969, HUTANUWATR *et al.* 1974, MCMANUS—CHOUNG 1976). MORTON—JUTRAS (1974) used silica (SiO_2) for estimating the nutritive value of forage.

The high content of silica in RH not only results in lower digestibility of the dry matter (HUTANUWATR *et al.* 1974, CHOUNG—MCMANUS 1976, MCMANUS—CHOUNG 1976), but may also be the cause of siliceous urinary calculi. The calculi in range cattle are formed from the silica in the different range grasses that are their main diet (BLACKMAN—BAILEY 1971).

Recently efforts have been made to improve the digestion in the rumen by keeping the pH of the rumen liquor at an optimal value. In this case the feedstuffs are supplemented with different puffer substances, for example Bentonit, Diamol, etc. These substances contain many kinds of microelements and 70—80% SiO_2. It has been verified that the large amount of SiO_2 promoted the digestion in the rumen and caused no toxic effects in the organism.

The solubility of silica is low and practically all the solid silica which is ingested should be excreted in the faeces. Some of the ingested silica is absorbed from the alimentary tract as silicic acid and this is normally excreted in the urine; in some individual sheep, however, solid silica is deposited in the urinary tract to form calculi (JONES—HANDRECK 1965).

A knowledge of the fate of dietary silica is necessary when using RH as a component of ruminant diets. In the present model experiments the recovery of the ingested silica in RH was measured in the faeces and urine, together with the concentration of silica in the rumen liquor and blood.

Three 6-month-old Merino wether lambs with an average live weight of 28 kg and fitted with ruminal canula were housed in individual metabolism cages. Three different diets were fed to the lambs in three consecutive trials. Each trial consisted of a 10 day preliminary period followed by a 5 day collection period. The three dietary treatments were:

Group I (control): 600 g barley, 200 g barley straw and 50 g molasses
Group II: 600 g barley, 200 g RH and 50 g molasses
Group III: 600 g barley, 200 g RH, 50 g molasses and 10 g urea

Each diet also included 4 g vitamin and mineral mixture (No. XIX. Phylaxia, Budapest). The diets were fed twice daily, while salt blocks and water were offered *ad libitum.* The RH used in this study contained 93.1% dry matter, 5.1% crude protein, 0.8% crude fat, 38.9% crude fibre, 32.9% nitrogen-free-extract, 0.93% silica-free-ash and 14.4% silica.

Short-term experiment. During the collection period, the total amount of faeces from each lamb were collected daily, weighed and an aliquot dried to constant weight at 60 °C.

At the end of the collection period, the faecal samples from each lamb were pooled and finally ground for silica analysis. Silica was determined in the feed and faeces according to ANONYMOUS (1965). Urine from each lamb was collected daily in a polyethylene collector. The urine volume was measured and silica was determined by the removal of phosphate according to KING *et al.* (1955).

On the last three consecutive days of each collection period, blood samples were taken from the jugular vein 3 hrs after feeding. The samples were deproteinized with trichloroacetic acid and analysed for silica.(KING *et al.* 1955). At the same time rumen liquor samples were obtained through the rumen canula and centrifuged for silica determination by the procedure used for silica analysis in the urine.

Owing to missed collections for lamb No. I during treatments II and III, the results of only two animals could be used in the analysis of faeces and urine.

Long-term experiments. At the end of dietary treatment III two lambs were penned together and were fed further on a daily ration of barley and RH for an extended period of 80 days. The aim of this long term experiment was to study the effect of feeding RH to lambs on the concentration of silica in the blood and also the role of silica in urolithiasis. The animals were killed and the urinary tract was examined for the existence of siliceous calculi. Histological studies were also carried out on the kidney, ureter and bladder.

JONES—HANDRECK (1965) stated that silica is absorbed from the alimentary tract as silicic acid, and it is in this form that silicon in transpcrted throughout the body. In this study all values are expressed in terms of silica (SiO_2) for ease of comparison.

Table 1

Intake of silica and its excretion in the faeces

Animal No.	Silica in feed		Silica in faeces		Recovery of ingested silica in faeces %
	g/day	%	g/day	%	
Treatment I					
1	6.26	0.86	6.20	2.77	99.0
2	6.57	0.89	6.57	3.10	100.0
3	5.08	0.75	4.86	2.60	95.7
Mean	5.97	0.83	5.88	2.82	98.2
Treatment II					
2	30.96	4.01	30.56	10.80	98.7
3	30.96	4.01	30.69	11.20	99.1
Mean	30.96	4.01	30.63	11.00	98.9
Treatment III					
2	30.96	4.01	26.48	12.98	85.5
3	30.96	4.01	29.06	11.96	93.9
Mean	30.96	4.01	27.77	12.47	89.7

In dietary treatments II and III, the silica in RH represented 93% of the total silica consumed by the lambs. The amounts of ingested silica and the total amounts excreted in the faeces are presented in Table 1. The percentage of silica in diet I was 0.83%, while it was 4.01% in each of diets II and III. The average daily silica intake was 5.97 g from diet I and 30.96 g from diets II and III. The amounts of silica in the faeces increased when the amounts of ingested silica were increased. The percentage of silica in the faeces on a dry matter basis increased from 2.8% in diet I to 11.0 and 12.5% in diets II and III, respectively. In spite of the different levels of silica intake, the recovery of ingested silica in the faeces was the same in treatment I (98.2%) and treatment II (98.9%). However the recovery of ingested silica decreased in treatment III (89.7%).

These results indicate that the use of the recovery of ingested silica as an indicator of digestibility depends upon the different ingredients of the daily ration. When the ration was supplemented with urea (diet III), the recovery of ingested silica was reduced. This decrease in the recovery of silica in diet III may be partly due to the higher concentration of ruminal silica obtained from the animals in these treatment (Table 2). NOTTLE (1966a) suggested that variations in silica digestibility were due to the variable retention of particulate silica within the rumen rather than the marked absorption of silica into the digestive tract.

Table 2

Mean concentration of silica in the rumen liquor and the blood as affected by the different treatments

Animal No.	Silica concentration in rumen liquor, mg SiO_2/100 ml	Silica concentration in blood, mg SiO_2/100 ml
	Treatment I	
1	8.4 ± 0.99	0.49 ± 0.05
2	8.1 ± 1.76	0.31 ± 0.08
3	11.2 ± 1.17	0.40 ± 0.06
Mean	9.2	0.40
	Treatment II	
1	—	0.98 ± 0.08
2	18.0 ± 1.54	1.08 ± 0.25
3	18.0 ± 0.58	0.86 ± 0.14
Mean	18.0	0.97
	Treatment III	
1	19.5 ± 1.24	1.00 ± 0.11
2	21.4 ± 2.09	0.98 ± 0.05
3	19.5 ± 0.96	0.73 ± 0.09
Mean	20.1	0.90

Each value is the mean ± standard error of three observations taken on three consecutive days.

Table 3

Excretion of silica in the urine

Animal No.	Mean concentration of silica (SiO_2), mg/100 ml	Total silica (SiO_2), mg/day	Recovery of ingested silica in urine, %
	Treatment I		
1	18.7 ± 1.95*	60.5	0.96
2	17.5 ± 1.73	71.8	1.09
3	21.2 ± 1.64	44.0	0.86
Mean	19.1	58.8	0.97
	Treatment II		
2	21.8 ± 1.81	177.3	0.57
3	26.3 ± 3.64	83.6	0.27
Mean	24.1	130.5	0.42
	Treatment III		
2	27.5 ± 7.42	135.2	0.44
3	26.3 ± 1.27	106.4	0.34
Mean	26.9	120.8	0.39

* Standard error.

Only dissolved silica is absorbed from the digestive tract (Baumann, quoted by BAILY 1976). In a study carried out by MCMANUS—CHOUNG (1976), the change in solubility of silica along the digestive tract was presumably associated with changes in the pH of the digesta. The latter investigators and the results of BAILY (1976) indicated that the reticulo-rumen is a major site for the absorption of silicic acid. The results of the present study indicate that the concentration of silica in the rumen liquor is directly proportional to the concentration of silica in the diet. The average concentrations of silica in the rumen liquor were 9.2, 18.0 and 20.1 mg/100 ml for dietary treatments I, II and III, respectively.

The concentration of silica in the blood was 0.40 mg/100 ml for diet I increasing to 0.97 and 0.90 mg/100 ml for diets II and III, respectively (Table 2). JONES—HANDRECK (1965) found that the concentration of silica in the blood was about the same (0.5 mg/100 ml) when the lambs were fed on a diet containing 8.5 g silica/day, but they found that when the lambs were fed on a diet containing 24 g silica/day, the concentration of blood silica increased to 0.67 mg/100 ml. There is a limit to the increase of silica in the blood, since the dissolved silica which enters the blood-stream from the digestive tract passes rapidly into the urine without increasing the concentration of the blood.

The amounts of total silica excreted daily in the urine ranged between 44—72 mg in diet I, and between 84—177 mg in diets II and III (Table 3). The differences in the mean values between the different animals within each treatment are also shown in Table 3. Considerable differences were also found by NOTTLE (1966b) in the mean values of total silica excretion for different sheep.

The results also indicated that the total amounts of silica in the urine increased with the increasing silica content of the diet (Table 3). A higher concentration of silica was found in the urine in treatment III (26.9 mg/100 ml) than in treatment II (24.1 mg/100 ml). The lowest concentration of urinary silica was found in treatment I (19.1 mg/100 ml). Nottle—Armstrong (1966) found that the silica concentration in the urine was 25.9 mg/100 ml when sheep were fed on a diet containing 3.65% silica. The recovery of ingested silica in the urine was about 1% for diet I and 0.4% for diets II and III. The relatively higher recovery obtained from animals fed on diet I was due to the fact that less silica was ingested from that diet compared with diets II and III.

It seems that there is also a limit to the total amount of urinary silica which is excreted daily. Jones—Handreck (1965) observed that the increase in the silica content of the diet beyond 2% did not cause a further increase in the amount of silica excreted in the urine. In the present work, the maximum amount of silica excreted in the urine was obtained from animal No. 2, fed on diet II (177 mg/day). The amount of silica in the urine obtained from animals fed on diet II or III was only about twice the amount of silica in the urine obtained from animals fed on diet I, although the amount of ingested silica in diets II and III was about five times the amount of silica in diet I.

Underwood (1962) stated that up to an intake of about 10 g silica/day the amount excreted in the urine increased and that it did not increase with further intakes. No relationship was found by Nottle (1966b) between urinary silica excretion and the apparently absorbed silica.

The limitation of urinary silica is explained by the fact the solubility of silica in the rumen appeared to be limited. As previously mentioned, the highest level of silica concentration in the rumen was found in dietary treatment III (20.12 mg/100 ml). The latter figure agrees fairly well with the 19.4 mg/100 ml obtained by Jones—Handreck (1965) when feeding sheep on 24 g silica per day. This level of ruminal silica appears to be the limit and approximates to the concentration of silica in a saturated aqueous solution (18—19 mg silica/100 ml at 39 °C). Jones—Handreck (1965) stated that since the concentration of silica in the rumen liquor is similar to that of a saturated aqueous solution, it probably sets a limit to the amount of silica which is available for absorption from the alimentary tract and this in turn determines the maximum amount of silica which can be excreted with the urine. Baily (1976) found that the rate of silica excretion in urine was associated with a 22 mg/100 ml concentration of silica in the reticulo-ruminal fluid in cows fed on prairie hay but with a concentration of only 9 mg/100 ml in cows fed on alfalfa hay. The results of the present study also show that as the concentration of silica in the rumen increased, the concentration of urinary silica also increased.

It can be concluded that the increase in the silica content of the diet from 5.97 to 30.96 g/day was associated with an increase in the concentration of silica in the rumen, which reached the highest level in diet III (20.12 mg/100 ml). This level appeared to be the upper limit. The soluble silica was absorbed and excreted with the urine and the undissolved silica was excreted with the faeces.

After 110 days of feeding RH to lambs, no increase in the blood silica concentration was observed for lamb No. 2 (1.09 mg/100 ml), but a slight rise in the blood silica concentration was noted for lamb No. 3 (1.22 mg/100 ml). However, when the urinary tracts of the carcasses were examined no urinary calculi were found.

The data of this experiment confirm the possibility of using RH as a component of the diet fed to lambs.

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Prepared at the Tanta University, Faculty of Agriculture, Department of Animal Production, Kafr El-Sheikh; Department of Physiology of the Herceghalom Research Institute for Animal Nutrition, Budapest

S. Mahmoud, B. Szegedi, B. Juhász

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FORUM

EVALUATION OF WHEAT YIELDS

PARTICIPANTS

ABONYI-PALOTÁS, J., *assistant professor* (József Attila University, Department of Economic Geography, 6701 Szeged, Táncsics M. u. 2.)

ÁCS, A., *professor* (Debrecen University of Agricultural Sciences, Department of Applied Farm Management, 4001 Debrecen, Böszörményi út 138.)

BALLA, L., *senior researcher* (Agricultural Research Institute of the Hungarian Academy of Sciences, 2462 Martonvásár)

BALOGH, Á., *business administrator* (Komárom County Association of Co-operative Farms, 2800 Tatabánya, Dózsa György u. 63.)

BAUER, F., *scientific consultant* (Vegetable Research Institute, 6000 Kecskemét, Kisfái 10.)

BEKE, F.,, *station manager* (Cereal Research Institute, 9761 Tápánszentkereszt)

BOCZ, E. *professor, head of department* (Debrecen University of Agricultural Sciences, Plant Production Department, 4001 Debrecen, Böszörményi út 138.)

BODNÁR, M., *professor, head of department* (Debrecen University of Agricultural Sciences, Department of Agricultural Economics, 4001 Debrecen, Böszörményi út 138.)

BÖRZSÖNYI, L., *research worker* (Central Statistical Office, State Administration Computer Service, 1015 Budapest, Csalogány u. 30–32.)

DEBRECZENI, I., *professor, head of department* (Debrecen University of Agricultural Sciences, Irrigation and Amelioration College, Plant Production Department, 5540 Szarvas, Szabadság út 1–3.)

ECSEDI, J., *professor, institute director* (Debrecen University of Agricultural Sciences, Institute for Production Development, 4001 Debrecen, Böszörményi út 138.)

FRENYÓ, V., *professor* (Eötvös Loránd University, Department of Plant Physiology, 1088 Budapest, Múzeum krt. 4/a.)

HUSTI, M., *chief agronomist* ("Béke" Co-operative Farm, 7753 Szajk, Petőfi u. 163.)

KÁDÁR, B., *professor* (Debrecen University of Agricultural Sciences, Institute of Agricultural Economics and Management, 4001 Debrecen, Böszörményi út 138.)

KEMENESSY, E., *retired professor* (Keszthely University of Agricultural Sciences, Plant Production Department, 8360 Keszthely, Deák F. u. 16.)

KISS, Á., *deputy director* (Vegetable Research Institute, 6000 Kecskemét, Kisfái 10.)

KISS, E., *deputy head of department* (Fejér County Council Executive Committee, Agriculture and Food Department, 8000 Székesfehérvár, István tér 9.)

KOVÁCS, I., *department head* (Ministry of Agriculture and Food, 1055 Budapest, Kossuth Lajos tér 11.)

LÁNG, B., *agricultural engineer* (Socialist Co-operation for Maize Production, Crop Production System, 7101 Szekszárd, Borkombinát)

LELLEY, J., *retired head of scientific department* (6721 Szeged, Vidra u. 1. III. 10.)

MOLNÁR, F., *co-operative farm president* ("Jóreménység" Co-operative Farm, 8125 Sárkeresztúr, Tanácsköztársaság u. 38.)

NÉMETH, S., *senior researcher* (Irrigation Research Institute, 5540 Szarvas, Szabadság út 2.)

NYÉKI, J., *professor* (Keszthely University of Agricultural Sciences, Institute for Agronomy and Plant Production, 8361 Keszthely, Deák Ferenc u. 16.)

PÁL, GY., *editor* (Editorial Office of Acta Agron. Hung., 2462 Martonvásár, P.O.B. 19.)

PÁSZTOR, K., *professor* (Debrecen University of Agricultural Sciences, Plant Production Department, 4001 Debrecen, Böszörményi út 138.)

PETRASOVITS, L., *professor* (Gödöllő University of Agricultural Sciences, Department of Water Management and Amelioration, 2103 Gödöllő)

PLETSER, J., *head of scientific group* (Agrometeorological Observatory of the Central Institute for Atmospheric Physics, 2462 Martonvásár, Somogyi Béla u. 18.)

SVÁB, J., *senior researcher* (Gödöllő University of Agricultural Sciences, Department of Agronomy and Plant Production, 2103 Gödöllő)

SZABÓ, B., *vice-president for production* ("Lenin" Co-operative Farm, 5431 Tiszaföldvár)

SZALAI, GY., *institute director* (Research Institute of the Gödöllő University of Agricultural Sciences, 3356 Kompolt, Fleischmann u. 2.)

SZEDERKÉNYI, E., *senior researcher* (Research Institute for Agricultural Economics, 1355 Budapest, Zsil u. 3—5.)

SZIEBERTH, D., *head of production unit* (Socialist Co-operation for Maize Production, Crop Production System, Production Management Unit, 8000 Székesfehérvár, Táncsics M. u. 6.)

SZILÁGYI, GY., *research worker* (Agricultural Research Institute of the Hungarian Academy of Sciences, 2462 Martonvásár)

TARCSAY, I., *head of sub-department* (Baranya County Council Executive Committee, Agriculture and Food Department, 7601 Pécs, Rákóczi út)

VÉSEI, Á., *head of department* (Komárom County Council Executive Committee, Agriculture and Food Department, 2801 Tatabánya, Felszabadulás tér 4.)

ZSIRAI, J., *chief agronomist* (Transdanubian Industrial Crop Production System, "Sallai Imre" Co-operative Farm, 2456 Besnyő, Petőfi u. 3—5.)

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PÁL, GY.: **In 1976 there were 145 state farms in Hungary with an average area of 6877 ha, while there were 1470 co-operative farms with an average area of 3491 ha each. The proportions of the main branches of agriculture (plant production, livestock breeding, subsidiary activities) in the state and co-operative farms are different. When evaluating the wheat production in the various types of farms do you think it right to compare the wheat yields of farms with different proportions of the main branches of agriculture?**

ABONYI-PALOTÁS, J.: Nowadays questions connected with wheat production are coming to the fore again. However, since the economic conditions have changed, it is understandable that the emphasis is now on different aspects of the problem.

The special attention paid to wheat needs no explanation: as Hungary's most important bread grain it plays an outstanding role in the food production of the country.

In the present phase of development the interests of the Hungarian national economy lie primarily in the intensification of production, which is closely connected with an increase in yields. Interests at farm level are concerned mainly with an increase in real income. It must be emphasized, however, that both at national economy level and in the farms the amount of investment required to produce a given yield, and the critical point beyond which an increase in investment is no longer returned is very important.

Another interesting question of great complexity is how to evaluate, using exact methods, the wheat production in farms with different natural, geographical, social and economic conditions (different soil types, microclimates, water supplies, economic circumstances, etc.).

In my opinion it is possible to compare farms with different proportions of the main branches of agriculture when evaluating the wheat production. Although the farm structure does influence (indirectly) the efficiency of wheat production, the decisive factor is not this, but the provision of the necessary material and staff conditions. The indirect effect may be felt when assistance is given in establishing the conditions required for wheat production.

ÁCS, A.: Differences in the proportions of the main branches of agriculture do not exclude the possibility of comparison. Certain ecological factors, such as the climatic conditions and the type of soil, are much more determinative. For example, the wheat yields of co-operative farms on the loess-table of Debrecen cannot be compared with those obtained on alkali soils.

BALLA, L.: Farms generally take the climatic, soil and economic conditions into consideration when deciding which main branches of agriculture to deal with and in what proportions.

Under certain special farming conditions, if the right crop structure is established, wheat production may be regarded as a subsidiary activity. The wheat yields of such farms cannot be compared with those obtained in farms where wheat production is a basic activity and the main source of income. For example, in hilly regions where the conditions are favourable for livestock farming and wheat is grown only on eroded soils of poor quality, the yields cannot possibly be as large as on medium heavy loam. In spite of this, farms still grow some wheat in these places, because specialization is not complete, and because the farms are still inadvisedly instructed or "expected" to grow wheat.

BALOGH, Á.: The functional interaction between trends in wheat yields and the proportions of the major branches of agriculture in a farm seems at first sight to be obvious.

After all, it is quite natural for farms to give preference to their main activities, and to make improvements mostly where they expect more rapid returns. Therefore, considering the actual possibilities for development, it is inevitable that certain branches are pushed into the background.

Taking the time factor into consideration as well, the present proportions of the main branches of agriculture can be explained from one point of view by this train of thought.

Experience supports the theoretically obvious fact that farms give the greatest attention to the branches which absorb most of their resources.

Thus, it is not ungrounded to suppose that the highest level of production can be expected from the branch of agriculture that represents the largest proportion of the farm's activities.

As far as the farms are concerned wheat is just one of the possible crops, so the yield level greatly depends on how the farm judges its potential profitability. Under intensive cultivation its importance within the crop production or even the total production of the farm increases, and since on average the wheat area represents a high (approximately 30%) proportion of the total arable area, it will result in an increase in the proportion of crop production. Practical calculations confirm this fairly well.

A positive correlation which is not very close, but is too big to be ignored (0.27), is found between the average wheat yield and the proportion of crop production within a given farm. Pure chance can be ruled out, since the calculations are based on a relatively large number of observations (1975–79 data of 31 co-operative farms in Komárom county).

Nevertheless, this train of thought does not hold water, partly because if other aspects are considered the reverse of the above correlation can also be proved, and partly because the large number of exceptions concealed by the averages suggests the absence of any correlation.

For example, in the farms ranked first to fifth on the basis of their average wheat yields the proportion of crop production is less than the characteristic value, and they take places between the 11th and 25th. Farms ranked first, second, third, fourth and sixth according to the proportion of crop production only occupy places between the 11th and 30th on the basis of wheat yield.

An analysis of county data, and even more so of national data, shows that in farms with a firm foundation and a high level of management the proportion of livestock is larger, while crop production is relatively neglected. But this reduction in the proportion of crop production is associated with higher than average yields. Developed livestock farming means that the subsidiary branches are likely to be at a similarly high level.

The relatively low profitability of livestock farming, on the other hand, points to the fact that its development has been made possible primarily by more profitable branches of agriculture such as crop production, for instance. (Owing to its volume and profitability the role of wheat in this respect is indisputable.)

A close interaction develops between the major branches of agriculture, and a polarization of this has a far reaching impact on the general organization of the farm. This interdependence does not, however, mean that a relationship between the characteristic proportions of the main branches of agriculture and wheat production has been proved once and for all. Wheat, as a potentially favourable source of income, is at the centre of interest in almost every farm, and the yield results decisively reflect the natural conditions, technical level and general organization of the farm.

In comparing wheat yields the role of the main branches of agriculture is, in my opinion, practically negligible.

Bauer, F.: The questions do not make it quite clear what the purpose of the comparison or evaluation is. The aspects of evaluation are different when, for example, it is made within the frame-work of a national wheat growing competition than when the evaluation is of an analytic character. The demonstration of badly proportioned cropping areas, farming under inadequate conditions, an incorrect choice of varieties, unjustifiably high cost levels, etc. is also a form of evaluation, but I think this is a case of competition rather than anything else. From this point of view wheat yields can be compared irrespective of differences in the proportions of the main branches of agriculture.

Bocz, E.: It is dangerous to compare the yields of wheat, or those of any other crop, unless they are obtained under nearly identical production conditions. Yield comparisons are most realistic in exact field trials set up using identical methods. In this case it is primarily the influence of soil and climatic conditions on the yield under identical conditions of nutrition, sowing structure, crop rotation, etc. which is registered.

Any other method of comparison is a compromise solution and it is impossible to draw conclusions on the cause of the results obtained.

There is little point in comparing the wheat yields of the two production sectors, as such a comparison would not be scientific, but it can be used to establish the average wheat yields of the two sectors in general. At the beginning the state farms exceeded the co-operative farms by far as regards the yield of wheat, etc. Later, as the standard of nutrition, variety, plant protection and of agrotechnics in general increased, the co-operative farms caught up with the wheat production of the state farms and a number have even overtaken them.

Bodnár, M.: To start with I should like to make a general remark which concerns almost all the questions raised in connection with the evaluation of wheat yields, and which has a theoretical or practical influence on the answers given to them or may even determine them to some extent.

A rational comparison of the wheat yields produced in different farms, areas and production regions is limited or contorted by numerous factors, but is not impossible in most cases. However, these limiting factors threaten the realistic nature of the comparison with very varying intensity. For example, where agriculture is highly specialized differences in the production and crop structure may make it quite unrealistic in any given country to compare wheat yields produced on farms of widely varying sizes, whereas the wheat production of farms with mixed (highly diversified) production and crop structures can be realistically compared.

Between these two extreme cases the limiting effects on the comparative evaluation of wheat production are naturally felt to a greater or lesser extent depending on how wide the differences in the crop structure are. Apart from this, the greatest obstacle to comparability is represented by natural conditions (soil quality, climatic conditions), i.e. by factors that, between certain limits, are independent of the yield levels produced mainly due to human intervention.

Finally, the possibility of comparison is also influenced (in a positive or negative direction) by the aim of the comparison. For example, when the comparison is made to determine the efficiency of investments (i.e. for economic reasons), only the natural conditions and, in the present case, the size of the wheat production branch can be regarded as major limiting factors.

Consequently, I am of the opinion that the varied proportions of the main branches of agriculture do not limit the possibility of comparing the wheat yields of farms in Hungary. For one thing, although farm size has increased at an accelerating rate in Hungary over the last fifteen years, and the production forces have developed dynamically, with resulting progress in concentration and specialization, no significant change in the ratio between crop production and animal husbandry, for example, has been observed up to the present day. In fact, even a substantial shift in ratio between these two branches of agriculture would not in itself have any particular effect on the fundamental conditions of wheat production. So I think that, in spite of the differences caused by Hungarian agricultural conditions in the ratio of crop production to animal husbandry, wheat yields can be compared.

The situation is different as regards the proportion of subsidiary (industrial, commercial, etc.) activities within the main branches of production. Greater differences in this respect may represent a serious obstacle to comparability. As to the size of this proportion, there may be a marginal point (or rather a zone) beyond which the comparison of wheat yields would be unrealistic. In my opinion the wheat yields of farms or regions where the proportion of subsidiary activities within the main branches of agriculture exceeds 50% (this figure is naturally disputable) should not be compared with the yields of farms with a much lower proportion of such activities.

FRENYÓ, V.: The share of the different branches of production within agriculture as a whole is determined by numerous factors. Among these factors an important role may be played by economic considerations which reflect the views of the farm management and of the central authorities. However, in most cases there is a dialectic interaction between the objective conditions of the farm and what is expected of it. The ratio of the main branches of agriculture to the subsidiary activities is ultimately determined by the soil conditions of the area, the local climate, the feasibility of irrigation and other circumstances. Often a well chosen subsidiary activity may temporarily counterbalance a possible reduction in profit in the main branches. So subsidiary activities should not be regarded as a necessary evil. Besides ensuring a profit for the farm it also satisfies the requirements of the population.

Thus, in farms where there are different proportions of various branches of agriculture the conditions are complicated. The yields of bread grains, primarily that of wheat, must nevertheless be evaluated, partly from the point of view of the farm's own standards, but also in comparison to the national average, particularly as referred to unit area.

The task is not an easy one, but it is not insoluble. In making a comparison various different conditions may be considered, but it is best to take the local climate as the starting point. The following climatic factors should primarily be taken into consideration: the number of sunshine hours and the total heat units in the vegetation period, since these are the most important environmental factors, which influence the development and yield of wheat but are independent of the cultural practices. Yield comparisons can only be made between farms where these two climatic or ecological factors do not differ very much.

After this the choice of variety and the method of fertilization can be considered, as factors under human control. Those that have proved the most efficient under the local climatic conditions must be chosen.

Even when the comparison is simply of an informative nature, rather than being part of an attempt to achieve the largest possible wheat yield, it is advisable to compare the yields as outlined above, based on the similarity of the local climate, and treat th other circumstances (i.e. yield potential of the variety, soil conditions, etc.) as correc tion factors.

KÁDÁR, B.: The proportions of the main branches of crop production do not influence the yield of wheat as long as they allow the right forecrop to be grown and the soil to be prepared in time. Thus, in my opinion the proportion of the main branches within the farm does not fundamentally inhibit comparison.

KISS, Á.: When evaluating the wheat production of different farms the proportions of the various branches of agriculture must obviously be expected to vary. For example, in a farm where crop production (cereal growing) is the main activity, wheat and maize, or possibly other cereals, represent the main branch of production, though peas (green and dry) or other vegetable or fodder crops may also be grown on a smaller area. In this farm the emphasis is definitely on cereal production, and if by any chance, due to unusual weather conditions, pea picking coincides with the wheat harvest, it is quite certain that the wheat, as a crop occupying a larger area and consequently giving a higher income, will be harvested first rather than the other crop, that provides a lower income. And vice versa, in a farm growing mainly fruit and wine work in the orchards and vineyards will have priority over the harvesting of cereals in the peak season. Thus the harvest will be delayed, resulting in considerable losses, with a much lower yield average than was expected from the standing crop.

KISS, E.: In Fejér county in 1977 cereals were grown on 66.7%, industrial crops on 9.5%, potatoes on 1.3%, roughage crops on 9.9%, succulent fodder crops on 6.9%, vegetables on 1.9% and other crops on 3.8% of the sowing area. The sowing area of wheat made up 28.8% and that of maize 34.8% of the total grain crop area. The returns from crop production sales are chiefly determined by the yields of these two crops, In 1977 the wheat yield average was 4,050 kg/ha on a national scale and 4,660 kg/ha in Fejér county. The conditions in the county are better than the national average, as reflected in the crop results.

In my opinion, when evaluating crop results the ecological regions of Hungary should be taken into consideration, and the country divided into good, medium and poor wheat areas.

LELLEY, J.: Before answering the question I should like to make it clear what I understand by "comparative evaluation". A comparison of the cereal yields in different farms will only be realistic and informative if it is combined with reliable, exact cost calculations. This means that when evaluating yield data the actual production cost per unit yield must always be given. The professional and administrative staff of the state and co-operative farms are so large that there can be no difficulty in carrying out exact cost calculations.

In any rationally and professionally managed farm the proportions of the different branches of agriculture are determined by the agroeconomic and agroecological conditions. Though these factors must be taken into consideration they do not exclude the possibility of comparing wheat yields. A yield comparison combined with profitability calculations is, in fact, desirable, as it may show up any deficiencies and poor management.

MOLNÁR, F.: There are great differences in the arable areas of state and co-operative farms in Hungary. The crop structure varies from farm to farm. In addition, the ratio of basic to subsidiary activities also varies. In my opinion the financial position of the farms should primarily be taken into consideration when evaluating wheat production. The "Jóreménység" co-operative farm at Sárkeresztúr was included in a survey carried out by the Ministry of Agriculture and Food. In the 300 farms which took part in the survey the efficiency, profitability and natural indices of the individual branches of agriculture were studied. In general, there is a close positive correlation between efficiency and the financial strength and professional and managerial level of the farm. The "Jóreménység" co-operative farm is a member of one of the leading production systems (KSZE = Kukoricatermesztési Szocialista Együttműködés [Socialist Cooperation for Maize Production]). In the 180 member farms included in the survey the relation between the land value (measured in gold crowns) and the volume of yield is $y = 28.04 + 0.89x$. The fertilizer consumption has a greater influence on the yield than the quality of the land. The amount of fertilizer to be used depends primarily on what degree of risk can reasonably be taken and on the financial strength of the farm.

NÉMETH, S.: The basis for comparability is uniformity. In evaluating wheat production it is not realistic to compare the yields of farms with different proportions of the main branches of agriculture, although in the case of a national evaluation differences in the proportions of the main branches of agriculture are not in themselves of decisive importance from the point of view of wheat production efficiency. This seems to be proved by the trends of wheat yields in the state and co-operative farms:

	State Farms	Co-operative Farms	Co-operative yield average as a percentage of state farm yield average
1963	2.06 ton/ha 100%	1.52 ton/ha 100%	74%
1970	2.55 ton/ha 124%	2.07 ton/ha 136%	81%
1978	4.48 ton/ha 217%	4.21 ton/ha 277%	94%

The faster rate of growth of the co-operative yield average in the above period was caused by a positive development of farm technology rather than by a change in the proportions of the main branches of agriculture.

NYÉKI, J.: The question must definitely be answered in the negative.

Wheat yields are influenced by innumerable factors, the most important being the ecological conditions (including cultural practices). Today the main branches of agriculture have hardly any influence on the yield level. The dominant role of fertilization in soil conservation and the optimation of cultural practices (soil preparation, sowing, plant protection, with sufficient machinery to ensure that these operations are carried out close to the optimum time) make wheat yields independent of the proportions of the major branches of agriculture.

When the intensity of livestock farming had a great influence on crop yields (the standard of the farm could be judged by the animal density) the relationship between the major branches was obviously close.

Soil quality was dependent exclusively on the organic matter produced in the farm, which was used to improve the fertility of the soil, and on the proper choice of precrops.

So today it is extremely difficult to find a common basis for the evaluation of wheat production, but the proportion of the main branches of agriculture is definitely not suitable for the purpose.

PÁSZTOR, K.: The evaluation and comparison of farms with respect to wheat yield is undoubtedly influenced by many factors and circumstances. In my opinion farms with different proportions of the main branches of agriculture can be compared, provided that the farming conditions on the wheat areas serving as the basis of comparison, as well as the technologies applied, are nearly identical. The only case when they cannot be compared is when the wheat is confined to peripheral areas where other crops cannot be economically grown, but where wheat production is still possible.

In this case the main point is to what extent the conditions suit any particular branch of agriculture, while the farm profile is of far less importance.

PLETSER, J.: The proportion of the main branches of agriculture has a considerable effect on the agrotechnical and other farming conditions involved in the development of the wheat yield. It is obvious that more intellectual and financial resources are invested in the main activity of the farm. Consequently, an objective comparison can only be made between yields produced under approximately identical farming conditions.

SZABÓ, B.: The present method of comparing the yields of various farm products is undoubtedly the source of many controversies.

Since wheat is an extremely important food crop, and since the profitability of many farms depends almost exclusively on the wheat yields, it is naturally at the centre of national interest.

A classification of the farms from this point of view is not the most decisive, but since rankings based on wheat yield have ethical aspects too, the population of the country follows the evaluation with great attention.

In fact, the present situation has its roots in the past, when farm managers had to plan the production of almost every crop according to a strict quota, so they felt no particular responsibility for the results.

Later this situation changed considerably, but the farms were expected to retain a certain wheat sowing area. Naturally this meant that optimum conditions could not always be created, which obviously resulted in great differences in yield even between fields within the same farm.

This situation did not change fundamentally even when the farms became considerably more independent. Farms managers generally did not have the courage to change the crop structure; the shadow of the past remained, and this is still true in many places even today.

This is basically how it has come about that almost irrespective of the ecological demands of the plant, wheat is grown nearly everywhere in Hungary, even if the yields, for the reasons given above, are not satisfactory. A change in the economic regulators, which in practice used the purchase price to maintain the size of the wheat areas, naturally played an extremely important role in bringing about this situation.

In farms where the management had sufficient imagination and courage to modify the crop structure the wheat yields increased much more rapidly, because once the right succession of crops was established optimum forecrops and soil conditions could be ensured for wheat. In addition, the Hungarian agricultural administration provided a high standard of nutrient supply and change of variety, which are the necessary preconditions for successful wheat production.

It can thus be said that to a certain extent tradition and compulsory orders determined the location of wheat growing areas in Hungary; this situation has only recently shown a slight tendency to become more rational.

VÉSEI, Á.: The comparison is permissible provided all the parameters influencing the yield are examined, analysed and taken into consideration. In farms where the proportion of livestock, particularly of large animals, is high, the replacement of organic nutrients will naturally be more favourable, and the activity of the soil biosphere will increase. Under equal soil conditions the structure and life of soil given organic manure will be better, and this definitely has a favourable effect on crop yields.

The climatic conditions (temperature, light, precipitation, air humidity, etc.), which can only be altered to a slight extent, naturally have a uniform effect on the crops, irrespective of the proportions of the main branches of agriculture.

If the comparison is made purely on the basis of the main branches of agriculture no conclusions can be drawn as to whether the wheat yields in a given farm are good, medium or poor.

ZSIRAI, J.: In the state and co-operative farms the proportions of the main branches of agriculture are different, since every farm naturally tries to adjust them to the local conditions and develop those promising a higher income, so as to make a profit. Nevertheless, wheat yields can, in my opinion, be compared, as the size and relative proportions of the main branches of agriculture do not decisively influence the yields which are or could be achieved, nor do they always ensure that the comparison will be realistic.

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PÁL, GY.: **In Hungary wheat was grown by 134 of the 145 state farms and 1450 of the 1470 co-operative farms in 1976. In these state and co-operative farms the proportions of the various branches of production (field crop production, vegetable, vine and fruit production, cultivation of other plants) within plant production as a whole are different. In your opinion is it correct, when evaluating the wheat production, to compare the wheat yields of farms where field crop production makes up different proportions of the total plant production?**

ABONYI-PALOTÁS, J.: I think that the wheat yields of farms with different proportions of field crops within plant production as a whole can be compared. At the same time, a higher proportion of field crops undoubtedly has potential advantages (e.g. increased specialization within reasonable limits, membership of a production system, and, last but not least, the concentration of financial resources and intellectual capacities). However, these factors do not exclude the possibility of comparison.

ÁCS, A.: To decide this question the sowing structure of field crop production, i.e. the proportion of wheat to the total arable area, should be taken into consideration. If, owing to a large wheat area, the proportion of forecrops is unfavourable (e.g. wheat monoculture), the comparison will be distorted.

BALLA, L.: If specialization is carried out within crop production, so that a farm produces vegetables, fruit or grapes as its main crop, this is obviously done because more favourable conditions can be provided for that crop. In this case wheat production is a subsidiary activity, so the yield will not be competitive.

BAUER, F.: Wheat yields can be compared even when there are different proportions of field crops within the main branch of production.

BEKE, F.: The comparison is reasonable if field crop production occupies about 40—60% of the total agricultural area. Areas smaller than that indicate a higher degree of intensity, which has either a positive or a negative impact on field crop production as well.

BOCZ, E.; A truly correct answer to the question can only be given if we know the order of importance of the factors affecting the wheat yield.

The most important factors are the nutrient level and the variety. However, the whole order of importance may be upset by extreme soil conditions, or by the water regime of the soil.

In addition to these factors, an increasingly important place is occupied by the crop structure, the consequent crop rotation, the wheat forecrop and the frequency with which wheat is grown after wheat.

Also, analyses reveal that the absolute order of importance of the factors breaks down when one or other factor is at a more or less optimum level in all the farms. This has happened, roughly speaking, with the nutrients required by wheat. In this sense no relative yield-increasing effect of the nutrient level can be demonstrated when comparing the farms. In the order of importance, natural factors and those resulting from the crop structure (crop rotation, forecrop, etc.) are placed first.

All in all, it can be seen that today, when differences between state and co-operative farms no longer exist with respect to the nutrient level, which is the most powerful factor, simple and scarcely differentiated comparisons are meaningless. The influence of site conditions and crop structure plays the dominant role in the size and causes of yield differences.

BODNÁR, M.: The data given in the question, which have not changed significantly in 1980, reveal that wheat is grown throughout the agricultural area of Hungary (except for 28—30 state and co-operative farms). In Hungary there is not a great deal of specialization within the main branch of crop production. This is shown, among other things, by the relatively small number of regions or farms of any size that are intensively specialized to vegetables, fruit and wine. According to the economic literature, intensive specialization means at least a 25—28% share of one of the above branches or a joint share of 40% of all three in the production value of the given region, district or farm.

FRENYÓ, V.: A comparison is always instructive and promotes development even when the result gives a favourable impression. In this case the economy of the farm is obviously well-run, which further strengthens the confidence and self-assurance of the management.

An unfavourable result, on the other hand, causes useful concern and makes the management consider the possibility of improvement, which might not happen if comparative data were not available.

As to the question proper, I cannot see any difficulty in comparing the yields of different farms. This can still be done even when the field crops are grown in different proportions. A comparison makes it possible to study the conditions in other farms where wheat production is either more or less efficient and to discover the positive and negative effects and the regularity with which they occur, on the basis of which our own yields can then be improved.

KÁDÁR, B.: I think it is reasonable to make such a comparison, since the different proportions of field or horticultural crops do not fundamentally determine the profitability of wheat production.

KISS, Á.: A comparison is obviously possible, and necessary, too, if national statistics are to be prepared, but the data obtained must be further analysed by experts (wheat breeders and agrotechnicians), whose task it is to explain why the yield was outstandingly high in one farm and extremely low, possibly even with the same wheat variety, in another.

KISS, E.: The percentage of the arable area sown to wheat has an impact on the yield averages. If this percentage is low a more favourable pre-crop composition and better soil preparation are possible.

Farms with a wheat growing area of 20—25% are in a more favourable situation and may attain larger yields than those where this proportion is 25—30%. Therefore, in the course of evaluation the ratio of the wheat area to the total arable area should be taken into consideration at farm level.

LELLEY, J.: If the farms to be compared are similar in character, the only differences being the proportions within crop production as a whole, there is nothing to prevent a comparative evaluation; in fact, it is definitely desirable in order to point out possible differences in profitability between the farms.

MOLNÁR, F.: In large-scale farms the proportions of various crops within the main branch of crop production vary considerably. In my opinion, for the purposes of evaluating the wheat production, a realistic comparison can be made between farms with nearly identical crop structures, provided there is no substantial difference in the general level of management and their site conditions are almost the same.

I think that the proportions of wine and fruit production within the farm can be ignored when evaluating wheat production, except when sowing is delayed during a heavy vintage (in October) due to a shortage of tractors.

NÉMETH, S.: Differences in the proportions of field crops within plant production as a whole naturally make the comparability of wheat yields in different farms questionable.

NYÉKI, J.: In a farm where vegetable, wine or fruit production is the main activity wheat yields are obviously not of decisive importance. Farms with higher area intensity mostly sow wheat on areas which, owing to their situation, soil quality, or distance from farm headquarters, are not suitable for intensive cultivation. Thus, wheat growing is at a disadvantage in these farms right from the start, not to mention the fact that, owing to the demands of the main crops, the agrotechnical operations are difficult to optimize. Consequently, the wheat yields of farms with different proportions of crops within plant production as a whole cannot be compared.

SZALAI, GY.: The proportion of the wheat area to the total arable area is nearly identical with the national average in most Hungarian farms. An exception, however, are the highly specialized farms, particularly those dealing with horticultural plants (growing vines, fruit, vegetables and medicinal herbs), and a similar situation is found in some farms specializing in growing maize. In these farms the emphasis is laid on the main crop, which fundamentally determines the profitability of the farm, and wheat growing is of secondary importance. So I think it is reasonable to compare the wheat yields of farms where wheat is sown on 20—40% of the arable area.

Farms where the wheat area is less than 20% of the total arable area of the farm are in a much more favourable position from the point of view of precrops and of getting work done at the optimum time. On the other hand, farms where wheat is grown on more than 40% of the arable area are under pressure and struggle with serious precrop problems. These are mainly farms in hilly areas, where the production of wide-spaced crops (maize, potato) is restricted in order to prevent erosion.

SZEDERKÉNYI, E.: The evaluation of wheat yields and the analysis of causal relations is not only important for research aimed at shaping the future but is also an indispensable condition for systematic, economical farming in everyday practice. So I think that from the point of view of a comparative evaluation there is every justification for questioning the value of the comparison. Comparisons must definitely be made, taking into consideration the importance of all production factors, the role they play in forming the yield, and their complex effect.

Wheat production is extremely important in Hungarian agriculture, so an objective analysis and comparison are becoming more and more necessary. In 1978 wheat was produced on 1324 thousand hectares (27.2% of Hungary's arable area), almost exclusively by large-scale farms. Owing to the economic conditions under which wheat is grown and due to the fact that it makes up a high proportion of plant production, a considerable proportion of the agricultural profits of large-scale farms is supplied by wheat production. Except for 1979, when the weather conditions were extremely unfavourable, wheat is the most profitable cereal.

The statistical system does not render it possible to analyse and compare large-scale wheat production according to variety, variety group or quality. In research of this kind a thorough, careful collection of data must be carried out. In our work the most important factors acting on the trend of yield (variety, growing region, fertilization) were evaluated on the basis of data collected in state and cooperative farms. The data basis covered 1,146,601 ha in 1976 and 1,185,738 ha in 1977, representing 89 and 93% respectively of the wheat area of large-scale farms.

It is only in the case of extreme soil conditions that wheat production is restricted. Even the need for crop rotation does not in fact limit the sowing area to any considerable extent. Provided fertilization and plant protection are properly carried out and resistant varieties are grown, sowing wheat after wheat has no harmful effect. Naturally, this involves a certain amount of surplus cost, but this can be compensated for by the advantages of large-scale production. The main determinant of the size of the wheat growing area is the degree of mechanisation, particularly the number and capacity of combine harvesters. The machinery currently used in Hungary requires a minimum wheat growing area of 400 to 800 ha.

Apart from the factors which influence the possible size of the wheat growing area, the proportion of wheat production within the arable area is determined by the farming and economic conditions of the farm, including where the main interest lies.

For the analysis the farm data were grouped according to the proportion of wheat production compared to the total arable and the absolute size of the wheat growing area, in an attempt to find a correlation between the degree of concentration and yield trends.

In the seven regional units of Hungary it was chiefly in co-operative farms where wheat was grown on less than 20% of the arable area that the wheat area did not reach the minimum practicable size. In the group where branch concentration was 20—40% the wheat area was as much as or sometimes far more than 400 ha in every case. In spite of the high branch concentration (41—46%) in the Kisalföld and the Nyírség (North-West and North-East Hungary, respectively), where the farms are relatively smaller, the wheat growing area was below the optimum size. In the Mezőföld (south-eastern part of Transdanubia) and the Danube valley the average wheat area of the co-operative farms exceeded the lower limit in all categories of branch concentration.

With the exception of the Nyírség the average wheat area of state farms everywhere exceeded the minimum size in 1976, while in 1977 it was mostly in farms where the branch concentration was less than 20% that the average wheat area of state farms in the Kisalföld, the Transdanubian hill-country, the Central Hills of Hungary and the Nyírség was below the minimum.

Branch concentration in the regional units where yields were better than the average for the farms examined is shown in Table 1.

As regards the wheat yield, the indix of branch concentration grouped by regional units ranges between 30 and 34% for above-average co-operatives and between 27 and 35% for above-average state farms. There is no decisive difference in the average size of the wheat area either. The average wheat area was 1,144 ha in the Tiszántúl

Table 1

Wheat area, branch concentration and yield average in regional units with above-average results (1976—1977)

	Average wheat area, ha	Branch concentration, %	Yield average, t/ha	Average wheat area, ha	Branch concentration, %	Yield average, t/ha
	1976			1977		
Co-operative farms						
Kisalföld	694	30	3.96	704	30	3.90
Mezőföld and Danube valley	859	34	4.58	971	31	4.73
Tiszántúl	1144	34	3.94	1108	33	4.33
Average for co-operative farms examined	780	31	3.84	819	31	4.05
State farms						
Mezőföld and Danube valley	1793	29	4.93	1811	27	5.23
Transdanubian hill-country	1418	31	4.32	1264	29	4.21
Tiszántúl	1806	33	4.04	1834	31	4.41
Average for state farms examined	1425	29	4.25	1429	28	4.41

(the region east of the river Tisza) and 694 ha in the Kisalföld in 1976; these values were 1,108 and 704 ha in 1977. In the Mezőföld and the Danube valley, where the largest yields were obtained, the average wheat area was 859 ha in 1976 and 971 ha in 1977.

The average wheat area in state farms was the smallest both years in the Transdanubian hill-country (1,418 and 1,264 ha respectively) and the largest in the Tiszántúl (1,806 and 1,834 ha, respectively).

On the basis of national data it can be established that with an increase in branch concentration the wheat yield average first rises, then declines in co-operative farms and state farms alike, as seen in Fig. 2. For the co-operative farms this tendency is clear both years, while for the state farms there was a break for the 31—35% category in 1976 and for the 36—40% category in 1977, but in spite of this the correlation is clearly visible.

The number of farms belonging to the different categories of branch concentration and the percentage distribution are shown below.

Wheat area as a percentage of the arable area	Co-operative farms				State farms			
	number		%		number		%	
	1976	1977	1976	1977	1976	1977	1976	1977
<15	87	78	7	6	5	5	4	4
16—20	89	70	7	6	8	14	7	12
21—25	144	159	12	13	24	19	19	16
26—30	270	284	22	23	28	36	22	30
31—35	328	334	26	27	28	26	22	22
36—40	202	200	16	16	19	9	15	7
41—45	86	81	7	7	7	7	6	6
46<	35	33	3	2	6	4	5	3
Total	1241	1239	100	100	125	120	100	100

There were 598 co-operative farms in the 26 to 35% concentration categories in 1976 and 621 in 1977, representing 48 and 50% respectively of the total number of co-operative farms. Of the state farms 56 and 62 (44 and 52%, respectively) could be placed in these categories. The figure reflects that the largest yield averages in both sectors are also found in this interval. Thus, on a national scale the concentration interval 25 to 35% is favourable for production efficiency.

All in all, on the basis of the data and of Fig. 2, it can be said that with the present methods of large-scale agricultural production, too much importance need not be attached to branch concentration, i.e. to the proportion of wheat production within the main branch of agriculture. The yields obtained in farms with different proportions of field crops can safely be compared.

VÉSEI, Á.: A comparison is permissible, because
- all operations — from sowing to harvesting — can be fully mechanized, so the manual labour requirement is not high;
- it can be combined with any crop, i.e. it is not antagonistic;
- the soil requirements can generally be satisfied in any farm.

ZSIRAI, J.: I think that even farms where the proportions of field crops within plant production as a whole are different can be compared for wheat yield because crop ratios do not affect the yields which can be achieved.

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PÁL, GY.: In 1977 cereals were grown on 65.8%, legumes on 1.5%, industrial plants on 7.0%, potatoes on 2.3%, roughage crops on 13.9%, succulent fodder crops on 5.5%, vegetables on 2.5% and other plants on 1.5% of the arable area of Hungary. However, the distribution of arable land in the various regional units is not uniform, so the proportions of the individual cultivated plants vary from farm to farm. Do you think that, in order to evaluate the production of wheat, the wheat yields of farms with different proportions of wheat area within the total field crop production can be compared?

ABONYI-PALOTÁS, J.: In my opinion, farms where wheat makes up different proportions of the total field crop production can be compared. It is well known, however, that the single crop system generally has a detrimental effect. Thus, on a farm where wheat represented the whole of the field crop production, this would exercise a negative influence on the yield. The single crop system involves surplus costs, resulting in less profit. Thus, the proportion of the wheat area to the total arable area of the farm can only be increased as long as it does not interfere with optimum crop rotation and wheat can be sown after the most suitable forecrop. On numerous farms in Hungary the single crop system has successfully been eliminated.

ÁCS, A.: My answer to the previous question applies in this case, too. The situation is somewhat better if papilionaceous crops (e.g. peas) are sown on a considerable proportion of the farm area; this has a favourable effect on the yield not only as a forecrop but from the point of view of labour organization as well. In fact, the proportions of the various branches of agriculture, the crop structure and the crop rotation vary from farm to farm, and these differences influence the yields. A comparison can be made provided these differences are taken into account. Strictly speaking, only the results of exact field trials can be compared, where only one factor varies while the others are constant (e.g. in variety trials).

BAUER, F.: Wheat yields can be compared even when the proportion of the wheat area to the total area of field crops is varied.

BOCZ, E.: The science of crop production has not yet reached the point where site conditions are registered so exactly that a parallel can be drawn between these data (and other yield factors) and the yield. It is to be hoped, however, that recent ecological research results will soon make it possible to eliminate these deficiencies and elaborate a more differentiated analysis of yields in different farms.

It is at least as important to be familiar with the constantly changing order of yield factors when analysing farm yields as it is to know them when planning field trials.

The proportion of the wheat area alone may influence the result of a yield comparison. It is not worth comparing farms and analysing yields until the methodology has reached the level outlined above.

BODNÁR, M.: The proportion of the cereal area in Hungary is relatively constant and only changes to a negligible extent. Admittedly, this proportion decreased from 65.8% in 1977 to 60.3% in 1978, but the data for 1979 and the projected figures for 1980 indicate that the cereal area will be stabilized for the next few years at about 61.5%. Thus, this relatively constant proportion does not cause any difficulty in comparing wheat yields. Moreover, the proportion of the wheat area within the total field crop production does not count as a disturbing factor either, since the proportion of wheat in the crop structure also has a nearly constant value on a national scale (28–30%) and is not expected to change much in the years to come. It is also true, however, that this 30% or so proportion of the wheat area (which also indicates the almost uniform distribution of wheat production over the agricultural area of the country) has developed under very different natural conditions, and this rather than anything else may distort the results of yield evaluation. In fact, a substantial resiting of the wheat growing area would not be practicable, apart from a reasonable increase in concentration, in spite of certain problems regarding economic efficiency resulting from the different site conditions. This is because the national economy needs the cereals produced under less favourable soil and other natural conditions, and at the same time the relative profitability of wheat production justifies growing this crop even under poorer conditions.

FRENYÓ, V.: This question is based not only on the fact that the wheat growing area varies from farm to farm. Obviously the situation is different for a farm specializing in wheat production than for a farm where wheat is grown on a small area or only occasionally.

In the first case the production technology is based on wide experience, there is a high degree of mechanization, an optimum supply of fertilizers and more efficient plant protection, while the professional staff are better qualified with respect to wheat production than on a farm concentrating on crops other than wheat.

Nor must it be forgotten that plot size also influences the microclimate of the stand, and the border effect may also vary considerably. Thus, in this case the objectivity of the comparison cannot always be ensured.

KÁDÁR, B.: From the point of view of evaluating wheat production the ratio of wheat, or of cereals in general, in the sowing structure may be a decisive factor in the wheat yield, due to the necessary crop rotation and agrotechnics. Therefore, in comparing wheat yield averages it is reasonable to form categories from this point of view (e.g. less than 30%, 30—40%, 40—50%, more than 50% cereals).

KISS, Á.: The comparison is permissible because the data are required for national statistics• However, the proportions and the major branches of production must definitely be taken into consideration. For example, the Szikra State Farm in Bács county is an excellent fruit and vine growing farm but due partly to the site conditions, its wheat yields have been poor for years. Optimum conditions for intensive wheat production can never be provided in this farm. The only factor which the farm management has attempted to optimize is perhaps the variety, and they now feel that they grow the one best adapted to the local conditions, but the sowing date, cultivation, weed control, harvesting and storage are all secondary questions compared to work on the main crops. In this farm there are also problems with the wheat varieties. The variety found best in one year produces a poor yield next year, while another variety that gives a poor yield one year yields surprisingly well the next year. Unfortunately, there is no wheat variety really well adapted to the sandy loam of the farm which is not oversensitive to extreme weather conditions. Thus, for these reasons the potential productivity of the wheat cannot be realized in this farm.

KISS, E.: The technical conditions in large-scale farms have substantially improved and are now nearly identical.

All the co-operative farms (62) and state farms (7) in Fejér county are members of some crop production system (KSZE, IKR, DINTER). Consequently, it is possible to apply up-to-date wheat production technologies irrespective of the size of the farm.

The yields of different-sized farms can be compared, since the wheat growing conditions are nearly identical.

KOVÁCS, I.: Prior to giving a more or less detailed answer to the questions I should like to note two things. One is that, except for loose sand, almost all the agricultural areas of Hungary are suitable for wheat production owing to the climatic and soil conditions of the country. However, the ecological conditions vary from one region or farm to the other, so different yields will be obtained from the same investment. The other thing is that under the Hungarian system of economic management the prices of certain agricultural products are manipulated. Farms operating under unfavourable conditions, for example, are subsidized by the government. The farm management should decide in what proportions the individual crops are to be grown on the basis of calculations and a thorough consideration.

The proportions of the main branches of agriculture in 1977, calculated at 1976 prices, were the following:

— vegetables	5.8%
— field crops	34.2%
— fruit	4.9%
— other crops	1.7%
Total plant production:	52.3%
— cattle	14.9%
— pigs	17.5%
— sheep	1.7%
— poultry	11.9%
— other animals	1.7%
Total livestock:	47.7%
Grand total:	100.0%

Within the national average there are naturally great differences between counties, regions and — above all — farms in the proportions between and within the main branches. In numerous farms one or more of the main branches listed above are missing, mainly for ecological and economic reasons. This does not, however, exclude the possibility of comparing the wheat yields of farms with different proportions of the main branches or of field crops. Wheat yields are determined fundamentally by the fertility of the land and the standard of the complex production technology applied in the farm. For this very reason the comparison is not only justified but also necessary.

LÁNG, B.: The yield average of a farm cannot be influenced by the proportion of the wheat area compared to the total arable area.

MOLNÁR, F.: There are few farms in Hungary where monocultural field crop production is carried out. In evaluating the wheat production it is reasonable to take the crop structure into consideration, as the effect of the forecrop is felt for a very long time. At the present level of development, if a farm grows too large a proportion of wheat the yield average may decline. As yet Hungarian agriculture is not capable either biologically or chemically of maintaining wheat production at a high standard on 30—40% of the field crop area.

NÉMETH, S.: A comparison of wheat yields in farms where the wheat area makes up different proportions of the field crop production will not give an objective picture. It is a well-known fact that wheat requires crop rotation; if wheat is sown after wheat for several years it results in a reduction in yield. The ratio of forecrops, particularly of papilionaceous plants, in the crop structure has a considerable influence on the yield of winter wheat.

NYÉKI, J.: It is probable that in farms where wheat is grown on a considerable proportion of the arable area, not only are the conditions for wheat production (soil, climate, mechanization) favourable, but the economic calculations also encourage the development of wheat production.

Farms with lower proportions of wheat obviously possess less favourable conditions. For this reason a comparison between the wheat yields of such farms would not have a sound basis and would probably result in incorrect conclusions being drawn.

PÁSZTOR, K.: The question can only be answered correctly if we know what conclusions we want to draw from the comparison. If the aim is to find out how efficient the wheat production of a particular farm is, not only the yields but the farming conditions and the technology used must be known before conclusions can be drawn. When, on the other hand, wheat yields in different years are compared, a clear picture of the trend in yield averages will be obtained provided no substantial differences in farming conditions have occurred.

An example of this is a comparison between the yield averages obtained in small plot and large-scale national trials at the National Institute for Agricultural Variety Testing and the national wheat yield averages [see: Búzatermesztés jelene és jövője, 1979 (Present and future of wheat growing). Ed.: Dr. A. Bálint].

The results obtained between 1961 and 1977 demonstrate that the small plot and large-scale trials and the national yield averages all show the same tendency, although the small plot trials were set up on much more homogeneous soil. The size of the sowing area may undoubtedly influence the comparison in that the optimum forecrop, sowing time and seed-bed are easier to ensure on a smaller area than on a larger one.

VÉSEI, Á.: In answering the question many aspects and factors must be examined and taken into consideration. In crop production good results can only be attained if the best possible physiological conditions are provided for the plants grown. The necessary nutrients must be supplied and the optimum area ratios determined, taking into account the fact that different plants have different effects on the soil and on one another.

Economical soil use, and thus high yields, can best be achieved in the crop structure of a farm if the ratio between various groups of crops is optimum. If wheat is grown on a large proportion of the arable area for a number of years, its yield will be unfavourably affected.

ZSIRAI, J.: The proportion of the wheat area within the total field crop production opens up different possibilities for the farms, so I do not consider the comparison to be reasonable in this case. Farms growing wheat on a relatively small area can choose better forecrops and sow wheat after crops which are harvested earlier, i.e. it can be sown at the proper time into soil which is adequately prepared and matured, which cannot be said of those which grow a larger proportion of wheat. The latter are automatically in a disadvantageous position, because some of the wheat will inevitably either follow crops which are harvested late, thus missing the optimum sowing date, or be sown after wheat. These differences exist right from the beginning and will only get worse during the cultivation period; I should therefore suggest only comparing farms where the difference in wheat area is not greater than 200 ha, though the larger area may have an equalizing effect, for example, as regards soil quality, distribution of precipitation, etc.

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PÁL, GY.: **The production area of each crop varies from farm to farm; in some farms it is below and in others above the level considered minimum from a technical and economic point of view. In 1977 the sowing area of wheat was less than 300 ha in 227 co-operative farms, and even in those farms where it was 300 ha or more it was often distributed in various districts or farm units. In your opinion, can farms with different wheat areas be compared when evaluating the wheat production?**

ABONYI-PALOTÁS, J.: In principle I do not see any difficulty in comparing farms where the size of the wheat production area differs. In my opinion, there is no need to determine the upper and lower limits of the production area even with a view to ensuring the conditions necessary for comparability. It cannot be emphasized too often that the decisive factors are a sufficient supply of up-to-date machinery, the selection of varieties best adapted to the local conditions and optimum farming techniques. Another highly important factor is, of course, the quality of the soil.

One reason why I do not think it necessary to fix the upper and lower limits of the wheat area for the sake of comparison is that even the "level considered minimum from a technical and economic point of view" varies greatly with place and time.

The data from co-operative farms support this statement in practice, too, as the correlation between the size of the wheat area (including those below 300 ha) and the yield average was not found to be very close.

ÁCS, A.: Farms with wheat areas of the same order of magnitude (measured in thousand hectares) can reasonably be compared. By the law of averages a large total area, composed of different quality plots with various forecrops, generally depresses the yield level. Where the ratio of the wheat area is relatively low it is easier to choose plots which are favourable for wheat growing. The proportion of the wheat area within the total field crop production of the farm is a decisive factor.

BALLA, L.: Before comparing the yield of a small wheat area with that of a large wheat-producing farm it is necessary to examine why the area is small. Basically, there may be two reasons for this. One is that although the farm has a large area it has been specialized to another crop or a different branch of agriculture, and wheat production is only a subsidiary activity. In this case its wheat yield cannot be compared to the yields of other farms. The other reason is that the farm has a small area. If a farm is properly managed, and wheat is one of the main crops, it may achieve better yields than the large farms in spite of its small area. Therefore the comparison is unacceptable. There are cases, however, of low yields being obtained in small farms where the conditions are suitable for wheat growing. This is obviously due to problems concerning the managerial and professional standards.

If the yields of farms producing wheat under identical conditions but on areas of different size are to be compared, the technical background must be investigated. If this is identical too, the yields may be compared. Comparisons will only give correct results if all the factors (fertilization, crop structure, personnel and technical conditions) are taken into consideration.

Bauer, F.: If the purpose of the comparison is a wheat growing competition the following categories are suggested:

category I	100— 500 ha wheat area
category II	501—1000 ha wheat area
category III	1001—2000 ha wheat area
category IV	over 2000 ha wheat area

There is little point in farms with wheat areas of less than 100 ha participating in the competition.

Beke, F.: The yields can be compared. Wheat is not necessarily the most profitable crop. On smaller farms other, more labour-intensive crops may be more profitable.

In the case of large farms faced with a labour shortage, however, wheat may be a better proposition.

Bocz, E.: At the present high standard of farming the absolute size of the wheat area may influence the wheat yield of individual farms or regions. This can be explained by the fact that farms generally concentrate their intellectual and financial resources on those crops which are sown on such a large area that the employment of experts becomes necessary. A larger area involves the application of more-up-to-date mechanical, chemical, etc. equipment and more advanced technology.

Today it is well known that a minimum area, below which up-to-date machinery cannot be economically used, can be determined for all crops (this is 200—300 ha for wheat).

In future, every farm should aim at a concentration which ensures at least one "basic unit" of wheat production. But it is another matter how many "basic units" of wheat will be sown compared to other plants when the natural conditions are taken into consideration and priority is given to the most economical solution.

All in all, it can be established that with higher standards of agricultural production the sowing area of the crop concerned must be considered in addition to the usual factors when comparing state and cooperative farms and analysing their yields.

Bodnár, M.: It is indisputable that an increase in the size of any branch of agriculture has a favourable effect on the efficiency of up-to-date large-scale technology. If the other production conditions are assumed to be constant, a larger area is able in itself to exercise a remarkable positive effect, not so much on the yield average but on the trend of production costs. Under such circumstances, farms where wheat is only grown on a small area, making it impossible to make full use of developed technology and machinery, will indeed become less competitive. With a view to making wheat a competitive part of Hungarian agriculture it would definitely be justifiable to increase the growing area, partly by a further concentration of wheat production in regions with favourable natural conditions, and partly by increasing the size of the fields even in less favourable areas. In wheat production, however, as in any other branch of agriculture, production factors other than the growing area (agrotechnics, technology) may also have a favourable influence on the cost-profit ratio. So it may well be (as is often witnessed in practice), that farms with adverse conditions as regards the growing area, but where the joint effect of the factors mentioned is favourable, are capable of producing wheat yields comparable to those obtained in farms where wheat is grown on a larger scale.

Ecsedi, J.: I shall answer the first four questions in a single point, since — though approached from different angles — they are all concerned with structural problems. Structural considerations occupy an important place in analysis. Their role varies to a great extent, however, with the subject and purpose of the analysis. In studying the utilization of agricultural resources (including the soil), for example, an analysis of the structure of farm and goods production is of basic importance.

In my opinion, in evaluating wheat yields the structure is far less important than in the above example. In other words, the structural factors mentioned in the questions do not have a decisive role in the development of the wheat yield. Perhaps most attention should be paid to the proportion of wheat within the total crop production and the extent to which it is concentrated. It can be seen, however, that a lower proportion and concentration are not always disadvantageous, but may, to some extent, be of advantage (e.g. more favourable crop rotation and precrops). On the other hand, as the result of a constant increase in farm size, the number of farms where the wheat area does not reach the technical and organizational optimum size is becoming less and less.

Therefore, I think differences in the conditions listed in the questions do not exclude the possibility of comparison. Considering the area of Hungary and the number of farms, care must be taken to differentiate and classify the units examined (e.g. farms) on the basis of only the most important criteria. Otherwise there is a danger of breaking down the test material so much that general conclusions can no longer be drawn from the analysis.

Frenyó, V.: The optimum or acceptable minimum area of wheat within a given farm is a debatable point. It may even depend on the sowing density or the tillering ability.

Furthermore, it must be remembered that for objective reasons, such as the topographic and soil conditions, the creation of large-scale wheat fields could not be carried out properly in many places; the smaller plots were simply ploughed together. Consequently wheat fields of a considerable size often display an almost mosaic-like pattern because of the varied soil conditions. If large-scale wheat fields are properly set up, the soil of a field will be homogeneous in quality.

A comparison may be justified when wheat production in an up-to-date large-scale field is compared to a similar field in another large-scale farm, or vice versa, when small, scattered wheat areas are compared to similar ones.

Kádár, B.: Farms with different wheat areas can be compared, but farms with wheat areas below 500 ha should be left out of the comparison.

Kemenesy, E.: In my opinion the average wheat yields of different farms cannot be compared, because the soil conditions, the climate, the crop production structure the agrotechnics, the economic situation, the animal density, the mechanization level, etc. all show great variations. With a view to pointing out differences in organization and management comparisons can only be made between farms with identical conditions. Thus, comparison is only justified and can only supply reliable information when made within the individual ecological regions.

Kiss, Á.: The comparison is necessary, but the causes must be taken into consideration if possible. In India, for example, the farms are extremely small, the majority being between 0.5 and 3 ha, while there are very few large farms. Over the last 8—10 years the peasants have learned to grow intensive Mexican wheats on these small areas (in the neighbourhood of Delhi and Karnal and in Punjab province), and they produce 6—8 tons/ha grain with the Mexican varieties Siete Cerros, Sonalika, Kaliansona, etc. under irrigated and moderately fertilized conditions, while under dry farming conditions these varieties yield only 0.7—1.0 ton/ha grain.

Thus, even very small farms are able to attain the yield level of the large cereal producing farms and research institutes (Indian Agricultural Research Institute, Delhi; experimental wheat-growing farms of the Punjab, Pantnagar and Varanase Universities). The advisory services of the Indian research institutes and universities organize demonstrations for the small farmers and make them acquainted with the intensive varieties and cultural practices.

Kovács, I.: The size of the wheat area within a farm is influenced by a great many factors. The total arable area of the farm and what crops can profitably be grown under its soil and economic conditions are decisive factors. The labour supply is also very important. All in all, I am of the opinion that wheat producing farms can be compared even when there is a considerable difference in the sowing area.

Lelley, J.: If there is a great difference between the farms in the size of the wheat area a comparative evaluation supported by economic calculations is justified, because it may give information as to whether the difference in sowing area between the farms is acceptable from an economic point of view. If such an evaluation is extended to cover the other major crops grown by the farm, it may indicate whether the wheat area should be further increased or reduced.

Németh, S.: A comparison between farms with extremely great differences in wheat area is not advisable because it leads to incorrect conclusions.

PÁSZTOR, K.: If the soil conditions and the technology are identical a comparison aimed at evaluating the wheat production is possible.

However, farms with large wheat areas usually grow wheat not only on good soils but also on poorer ones, so it is difficult to ensure a suitable precrop, a well-prepared seed-bed and the optimum sowing time, i.e. to optimize all the stages of the technology. This may influence the correctness of the evaluation.

SZALAI, GY.: Except in extreme cases the wheat yields of farms growing wheat on areas of different size can be compared. Under Hungarian conditions, however, I consider 200 ha to be the minimum size.

TARCSAY, I.: In Baranya county wheat is grown on 26% of the arable area. The gross production value of wheat in 1979 was 700 million Ft, 20% of the total crop production value. The wheat yield averages of farms in this county are among the highest year in year out. They surpassed the national average by 2.7 q/ha in 1978 and 7 q/ha in 1979.

Since 1967 the yields of farms growing wheat on less than 300 ha, between 300 and 600 ha and more than 600 ha have been examined. Taking the effects of specialization into consideration, in 1979 the basis of the evaluation was changed by setting up categories of less than 500 ha, 500—1000 ha and over 1000 ha.

During the 13 years examined areas below 300 ha yielded less each year than the intermediate category, while those above 600 ha yielded more in 10 cases and less only three times.

In 1978 the average wheat yield was 31.7 q in farms with wheat areas of less than 300 ha, 44.9 q on areas between 300 and 600 ha, and 45.3 q on areas over 600 ha.

In 1979, after the categories had been changed, the average wheat yield was 35 q up to 500 ha, 40.1 q between 500 and 1000 ha and 41.3 q above 1000 ha.

Farms with wheat areas of different size cannot be compared, since the deviation is quite large even when categories are set up.

The differences in average yield between the farms ranged from 19—52 q on areas below 500 ha, 26—55 q in the 500—1000 ha category and 28—52 q on areas above 1000 ha.

VÉSEI, Á.: If the percentage of the wheat area to the total arable area is identical (e.g. 20% of 2,000 ha or 20% of 800 ha) the farms can be compared, otherwise they cannot, because in a farm where the percentage of wheat in the arable area is larger, even yields which are 100—200 kg/ha lower carry more weight than 100—200 kg/ha higher yields obtained on areas which represent a lower percentage.

In our opinion, 300 ha and 1,000 ha wheat areas, for example, can only be compared if they make up the same percentage of the total arable area.

ZSIRAI, J.: Area categories should be set up according to the size of the growing area; the wheat yields of farms belonging to the same category could then be realistically compared. The categories might be: 0—200 ha, 200—500 ha, 500—1000 ha, 1000—2000 ha and over 2000 ha.

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PÁL, GY.: **The difference in yield arising on land of identical size but different quality, given identical investments and under economic conditions which are average in all respects, forms the basis for the differential land rent No. I. The monetary basis, on the other hand, is the permanent extra income, which is one of the major reasons for the differential incomes of the farms. In evaluating the individual farms do you think it right to compare the wheat yields of farms with better soils situation and more favourable climatic conditions to those of farms working under less favourable conditions?**

ABONYI-PALOTÁS, J.: To the question of whether farms with better quality soils, in a better situation and with favourable climatic conditions can be compared for wheat yield to those with less favourable site conditions, my answer must be no.

In order to give an exact answer to the question I have studied the wheat yield data of co-operative farms in Csongrád county and have drawn the following conclusions. There are considerable differences in land quality even in a county with an area of only 4263 km^2. A surprisingly wide variation is found in the weather conditions too. From among the numerous quantifiable factors expressing the quality of the land I have chosen the gold crown value, an index which is rightly criticized but cannot at present be replaced by anything better. When the average gold crown values of the 1979 wheat areas of the co-operative farms are mapped together with the average wheat yield per ha of the co-operative farms during the same period, the two maps show quite a close similarity (Figs 1 and 2). Since the informative value of the two maps was substantially reduced when the data were placed in three categories each, a correlation was calculated from the time series on the basis of the original data. The result was a

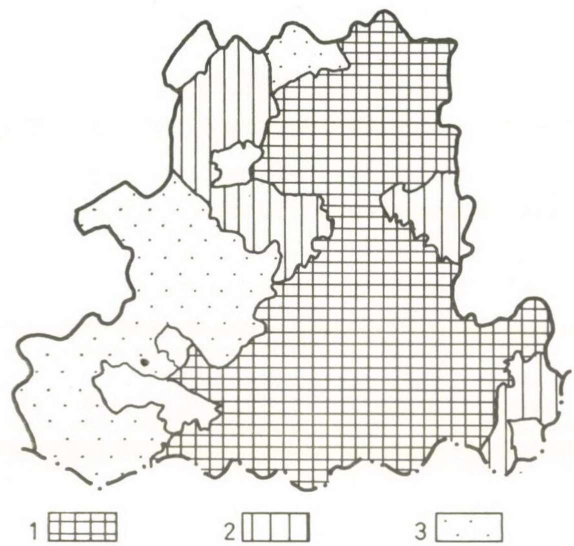

Fig. 1. Gold crown value of co-operative wheat area in county Csongrád (1979). 1 = up to 19 gold crown; 2 = 20–25 gold crown; 3 = above 26 gold crown

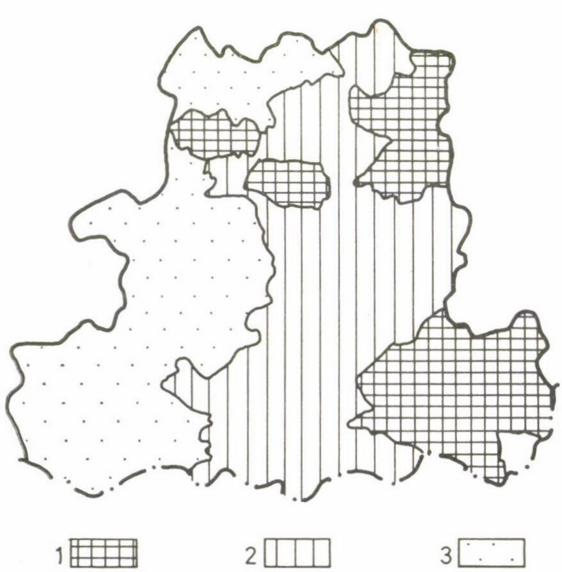

Fig. 2. Yield average of wheat in the co-operative farms of county Csongrád. 1 = above average (34.1 q/ha); 2 = average (28.1–34.1 q/ha); 3 = below average (–28.0 q/ha)

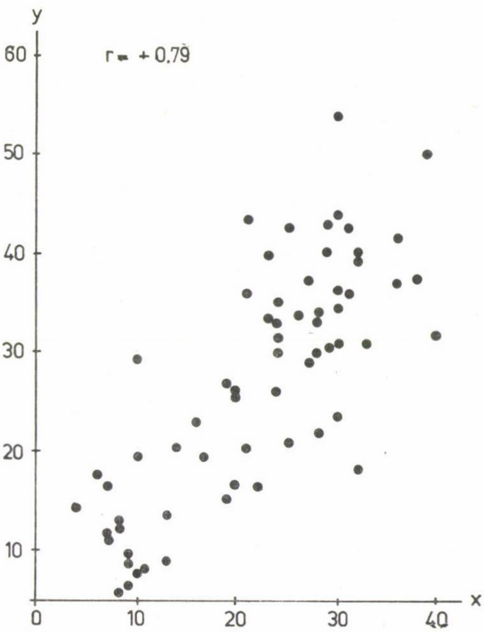

Fig. 3. Correlations between land quality and yield average. x = average gold crown value of co-operative wheat areas in county Csongrád; y = yield average of wheat in the co-operative farms (q/ha)

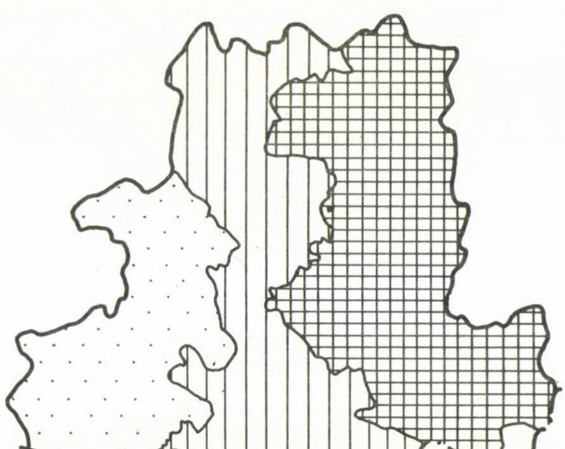

Fig. 4. Regions of county Csongrád. 1 = Maros—Körös mid-region; 2 = Lower-Tisza valley; 3 = Csongrád sand-table

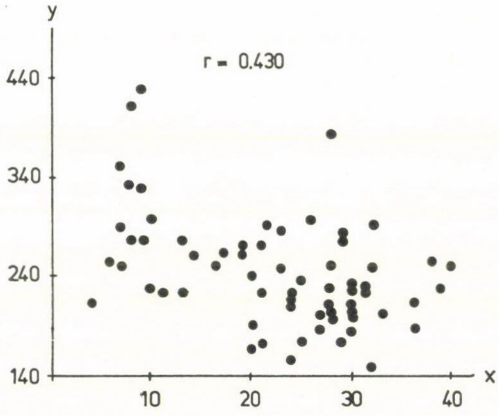

Fig. 5. Correlation between land quality and prime cost. x = average gold crown value of co-operative wheat areas in county Csongrád; y = prime cost (Ft/q)

correlation of +0.795 between the average gold crown value and the average yield of wheat areas in the co-operative farms (Fig. 3). This fairly close correlation means that the land quality, which can be characterized by the gold crown value, determines the yield on the area in question to some 63%. When calculating this two-factor correlation a very large number of other factors were naturally ignored; however, there is unlikely to be any distorting effect, because it is highly probable that they balance each other out.

The strong influence of land quality on yield is shown from a different aspect by the similarity between the three regions differentiated by soil properties (Fig. 4) and the map of wheat yield averages on co-operative farms (Fig. 2).

Table 1

Average wheat yields in the different regions

Region	1978		1979	
	q/ha	%	q/ha	%
Maros—Körös mid-region	46.5	100.0	38.9	100.0
Lower Tisza valley	38.8	83.4	27.1	69.7
Csongrád sand-table	24.0	51.6	13.8	35.5

Table 2

Average wheat yields in the different regions

Region	Percentage distribution of yield	
	1978	1979
Maros—Körös mid-region	52.8	59.6
Lower Tisza valley	39.1	34.6
Csongrád sand-table	8.1	5.9
Total	100.0	100.0

In this context I should like to refer to another correlation. Wheat is grown in all three regions of Csongrád county, but since these regions have different properties, the efficiency of wheat production also differs (Fig. 5). However, if the weather conditions are unfavourable these differences generally increase (Table 1).

Thus, in comparison with the Maros—Körös mid-region, which had the highest average, the yield average in the Lower Tisza valley and the Csongrád sand-table was 16.6 and 38.4% lower respectively in 1978, and 30.3 and 64.5% lower respectively in 1979 (a series of unfavourable factors). The percentage distribution of the harvested crop showed the same tendency (Table 2).

Table 2 undoubtedly shows this tendency well, but there are also examples to the contrary in the county. Under favourable weather conditions it often happens that land with a lower gold crown value produces better yields. In such cases only a thorough examination can reveal what role the human factor has played in the higher yields.

ÁCS, A.: There is undoubtedly a close relationship between the quality of the soil and the yield. Although the gold crown, as the standard of soil quality and natural productivity, has been considered out-dated for some time, it cannot yet be replaced by anything better. The statistical data unequivocally prove that the groups formed by the gold crown value are also characteristic of the yield average differences. The comparison will thus be realistic if the gold crown values of the respective production areas are taken into consideration. This should be the basis for the statistical grouping of farms and they should be compared within the groups.

BALLA, L.: In the last two decades yield differences due to differences in the size of the production area have decreased as a consequence of intensive cultural management, particularly the better nutrient supply, and the introduction of intensive wheat varieties. The yields have been equalized. There are even examples of larger wheat yields being obtained on land of poorer quality. In the case of extreme weather conditions, however, differences due to the soil quality arise. In dry years, for example, large differences are found between the yields obtained on low-lying, heavy soils and on high-lying, loose soils. Furthermore, extremely good and bad soils give different yields even under equal conditions, so they should not be compared.

BALOGH, Á.: A direct comparison between the specific wheat yields of farms causes serious problems in practice, as the site conditions are more or less different in every case.

A simple comparison results in considerable errors not only with wheat but with all crops whose yields are decisively influenced by the natural conditions. With present farming standards, most of the field crops grown in Hungary belong in this category.

Under Hungarian conditions, the fact that yields vary even though the same production technology is applied can be explained principally by differences in the quality of the land, apart from some extreme local conditions.

If sufficient data are available it can be numerically proved that with nearly identical investments better quality land gives higher yields than poorer land. With statistical methods the relation between land quality and yield can be proved in general, although in this case the identical investments and the completely normal production technology are not taken into consideration at all.

With respect to the relationship between land quality and yield I have made some calculations using the wheat yield data for 1970—1976 and 1979 from the 35 (now only 32) co-operative farms in Komárom county.

The condition that the technology should be identical obviously cannot be fulfilled in calculations of this character, but the amount of fertilizer active agent used for wheat production in the farm can be regarded as a suitable criterion for classification. (The close positive relation between the amount of fertilizer and the yield is well known.)

In the 4 groups formed on the basis of the amount of fertilizer active agent used per unit area the correlation between land quality and yield (taking the average wheat yield for 1970—1976) ranged from 0.66 to 0.87, i.e. a close positive correlation could be pointed out.

For the 1979 data a somewhat complicated but more exact method was applied nvolving several parameters, but the fertilizer consumption was deliberately ignored. The value of the linear correlation coefficient, obtained as the quotient of the covariance and the product of the standard deviations of parameters x, y, was 0.28 in this case which, while suggesting a relatively weak correlation, definitely excludes the possibility of a spontaneous chance correlation.

When the same calculation was made using the average yields for 1970—76 a fairly close correlation (0.62) was obtained, but in my opinion this still underestimates the importance of land quality.

One reason for the difference between the results of the two types of calculation is obviously the fact that the numerically defined natural fertility of the soil can be decisively influenced by the production technology. Many examples prove that with a high standard of farming larger yields can be regularly obtained from poor quality land than are produced on better land with a poor standard of cultivation. (The fact that the net income does not follow this analogy, and that extra income is usually obtained from better land in spite of differences in the level of cultivation, is, of course, a different matter.)

Another explanation is that land quality indices are unreliable and no longer show the natural fertility of the land in an objective way. This cannot be taken into consideration, however, since for the time being the gold crown cannot be replaced by anything better as a means of expressing the land quality.

If a comparison is to be made at all it is necessary to treat the qualitative parameters of the land as objective indices, in spite of our reservations. The key to the problem might be an evaluation that showed the extent of yield increase or decrease caused by a unit change in the quality of the land. It follows from the calculated correlation values that no equation can be set up to describe the correlation between land quality ("x") and yield ("y"); the correlation is only probable. (The possible values are between -1 and 1.)

In the case of a sufficiently large number, however, the values in the centre of the scatter approximate well to a regression line, which suggests that a linear correlation exists between land quality and yield. This fact is of great theoretical and practical importance as it provides a basis for comparison.

Basically, a particular solution must be found for a multivariable regression function in which $\bar{x}_1$ represents the average land quality of the farms included in the calculation, while $\bar{y}$ is the average wheat yield of the farms.

The other factors ($x_2 \ldots n$) are considered to be constant, since the whole point is to take only the varying land quality into account in the course of the evaluation.

The solution involves the determination of the elasticity of y against x_1, i.e. the relative change caused in "y" by an increase or decrease of say 1% in "x_1".

A numerical definition is possible by making use of empirical results and theoretical considerations.

In determining the empirical value of the elasticity the obvious way is to use the data of farms which produce wheat within the framework of a production system and are members of the same system, since in this case the assumption that all the farm conditions except land quality are average or nearly so and can consequently be standardized or even omitted from the calculations is acceptable.

The 1976—78 wheat yield data in those co-operative farms of Komárom county which belong to the Baja Maize Production System show that a 1% change in land quality compared to the average conditions results in a 0.45% change in yield. In my opinion, this value is acceptable even on purely theoretical considerations. Using this and taking a mass average as the starting point, the wheat production of most Hungarian farms can be evaluated on a fairly objective basis.

Taking the characteristic data of Komárom county (arable land to the value of 18 gold crowns, 4100 kg/ha yield) as a basis, a yield of 3800 kg/ha obtained from land with a value of 20 gold crowns, for example, would be regarded as only 88% efficiency, since a yield of about 4300 kg/ha would be the equivalent.

With this method the calculation is simplified, involving only the setting up and solving of an equation with a single unknown quantity, so it is relatively easy to carry out.

The 0.45% value of the elasticity coefficient naturally needs correction from time to time even under the conditions of Komárom county. It can be shown that at a low technological level the value of "x" determines that of "y" to a greater extent, and vice versa.

In outlining this method I hope also to have answered the question of how an exact evaluation of the yields of wheat-producing farms could be carried out. In spite of its obvious deficiencies (which most statistical methods have) I think it might lead to the elaboration of more advanced methods.

BAUER, F.: Besides the size of the sowing area the quality of the soil should also be taken into consideration when establishing the categories for comparison. This will not be possible, however, until a uniform soil classification system is introduced. This should be based on the average value for the total arable area of the farm.

BEKE, F.: The comparison in question is not possible. Any comparison would require a classification of the farms even within a given region, as the heterogeneity of a region may be extremely high.

BOCZ, E.: It has long been a grievance of managers of farms with poorer natural conditions that praise is always given to the managers of farms with good conditions where the larger yields are more easily attained. On areas with unfavourable conditions, alkali soils, etc. lower wheat yields are obtained in spite of the relatively harder work of the staff and higher investments. It is hardly necessary to explain why the wheat yields of such areas cannot be compared.

BODNÁR, M.: There can be no doubt that apart from human intervention the fertility of the soil has the greatest differentiating effect on crop production in general, and naturally on wheat yield averages as well. Wheat yields obtained on the poorest soils certainly cannot be compared with those produced on good quality land with the same level of investment. However, it should be noted that strong distorting effects are only likely to occur in the case of extreme values, i.e. when the products of the worst and best quality lands are compared. But even so, regular correlations are not always found. For example, if we consider the wheat yield averages obtained in Békés and Szabolcs-Szatmár counties, which represent the opposite ends of the scale as regards the gold crown value of the land, we find that in 1978 and 1979 the difference in yield per ha was only 36 and 32%, respectively, although the difference in soil quality was 114%. Furthermore, recent economic studies have led to the conclusion that in the case of a high standard of investment the yield differences caused by differences in natural fertility will be reduced.

This is confirmed by the data of the correlation analyses mentioned above; within the extreme values there are cases in Bács-Kiskun county, for example, where the average wheat yield on land with a soil quality of 18.51 gold crowns/ha was only 300 kg (9%) lower over a two year average (1978—1979) than in Békés county where the gold crown value of the land is 29.81 (61% higher than in Bács-Kiskun county).*

In my opinion the wheat yields obtained on different quality soils can be compared, because the evidence of the relevant research and practical experience shows that at the present high standard of farming it is deliberate human intervention and the proper allocation of financial and intellectual investments, rather than the other production factors (including the natural conditions) that are more than 65% responsible for the yield. In order to make the comparison more realistic it is advisable to use a correction which takes into consideration the scientifically based economic calculation which shows that farms with unfavourable natural conditions need a 10—15% higher investment to attain the same yield level as those with better natural conditions.

ECSEDI, J.: The growing site conditions in general, and the quality of the land in particular, have a decisive influence on crop yields, including that of wheat, but they also have an effect on the size, composition and efficiency of the investments, the possibility of increasing the supplementary investments, etc. Therefore, in evaluating wheat yields the correct way is to compare the data of farms with similar site conditions. Of course, the yield averages of farms within a county or production system can also be compared, but this will only give a general view of the situation. It would be a mistake to use such a comparison for the classification of the farms.

FRENYÓ, V.: Wheat yields can only be realistically compared (if investments are ignored) under more or less identical soil and climatic conditions. This does not apply to the potential yield, however, as proved by the fact that the yield difference between two farms situated near to one another in the same regional unit may be as high as 50%

* It must not be forgotten, of course that measuring land quality by the gold crown value has become rather out-of date and only gives an approximate indication of the actual state of fertility; however, exact calculation methods are not available as yet.

in the same year. The professional knowledge and adaptability of the staff play an important role. For example, one expert, who had to grow maize on a non-irrigated area, calculated the amount of water retained in the soil after an autumn and winter period poor in precipitation. On the basis of the transpiration coefficient, an important index of plant physiology, he calculated how many plants could be raised with the available water assuming a minimum amount of precipitation. He adjusted the amount of seed accordingly, distributing a smaller quantity of seed over the area. As a result he achieved an acceptable yield when other farms in the neighbourhood suffered serious losses.

KÁDÁR, B.: Large-scale farms whose farming activities cover several different localities have land with different fertility, soils and topographic conditions. These areas show variations even within the farm. It is obvious that any realistic comparison can only be made within groups distinguished according to the farming conditions. The comparison suggested in the question, while possible, will thus not give a true picture.

KISS, Á.: We are compelled to make a comparison, but at the most it will demonstrate why wheat production should be encouraged in one farm and reduced in another. Where the conditions are optimum for growing high quality wheat, this should be given preference. On the other hand, where the unfavourable ecological conditions mean that a potentially good quality wheat only yields a medium or poor quality crop, the emphasis should be laid on wheat varieties of poorer quality but which give high yields.

KOVÁCS, I.: The question touches on the most important factor influencing the profile of a farm, since the farm profile, including crop structure, i.e. the ratio of the individual plants to the total arable area, is determined by the maximum possible profit which the farm can achieve. Many farms construct a preliminary model aimed at deciding the optimum farm structure which will give the highest profit.

LELLEY, J.: A yield comparison between farms with unfavourable and favourable ecological conditions is only justified when it is complemented with authentic economic calculations. Such a comparison may give information as to whether the wheat area should be replaced by a more useful crop, or on the contrary, should be extended at the expense of other crops.

MOLNÁR, F.: When comparing farms with areas of identical size but different quality, the quality of the land must be taken into consideration to some extent. From the point of view of the attainable yield the quality of the land is of less importance today, but the physical characteristics of the soil must definitely be taken into account. The relationship between the gold crown value and the yield has already been mentioned.

NÉMETH, S.: The wheat yields of farms with favourable conditions can be compared with those obtained under poor conditions if the evaluation is aimed at demonstrating the surplus income.

NYÉKI, J.: The comparison is something of a problem, because although farms with less favourable conditions may reach the yield level of those possessing favourable conditions, this can only be achieved with considerably higher investments. The progress in the economic life of the country necessarily involves a process whereby wheat production is restricted in farms less suitable for wheat growing, giving place to crops yielding a higher profit from lower investments (intensive grazing land, fruit, etc.).

In the development of wheat production an extremely interesting process in taking place. The rye producing area of Hungary was reduced once the state of the soil made it possible to grow wheat. Owing to its higher yield potential wheat has not only become competitive with rye, but now produces much larger yields. Thus, in spite of the worse conditions within the regional unit, farms where this change has been made are now in a relatively favourable situation. This does not mean, however, that the wheat yields of farms in the Mezőség, for instance (a region in the eastern part of Transdanubia) can be compared with those obtained on areas used for wheat production out of necessity, and where the wheat area may change or possibly be reduced according to the export trends.

Pásztor, K.: Wheat yields can only be compared if they have been produced with the same technology on soils of identical quality. The aim of the comparison must also be taken into consideration. In the case of soils with identical fertility where different production technologies are used conclusions can be drawn from the yields on the efficiency of the technology, or when different varieties are grown it can be concluded which of them are best. A comparison can only be made between yields obtained under the same production conditions.

Pletser, J.: The yields obtained on areas of identical size but different quality and climate, with equal investments and average economic conditions, depend on the soil and climatic conditions. A comparison is only justified if the aim is to determine the minimum soil and climatic conditions under which it is still worth growing wheat. For the purpose of evaluating farm efficiency, however, only farms operating under ecological and economic conditions identical in all respects can be compared.

The climate of a region is a complex of various meteorological factors. It follows that the yields of a single year cannot be evaluated according to the climate; the average of at least ten years' yields should be taken into consideration.

The effect of the changing weather conditions in Hungary, especially of the uneven distribution of precipitation in time and space, may be felt in the yields from year to year. The yield differences are often greater than the differences in the average climatic conditions. This is particularly so in years when some elementary damage occurs on areas with otherwise favourable climatic conditions. For example, in the 1978—79 crop year an autumn drought was followed by cold winter days without snow, after which a dry spring, and particularly a hot, dry May reduced the yields. Where these phenomena were moderate, the yield was better. But it was obviously not the merit of the farms that the autumn was rainier in that region than elsewhere, so that the frost caused less damage in the stronger stands. After this type of weather it sometimes happened that the spring was not as dry as elsewhere. Some of the fortunate farms claimed that the yields attained were exclusively due to good management and they decided to increase the proportion of wheats of Mediterranean origin.

The total amount of precipitation in Hungary in the three autumn months (September, October, November) ranged from 26 to 120 mm, which is 15—80% of the long-term average. Wheat obviously developed better in places where the amount of precipitation over the three months was almost 80% of the long-term average than where it was only about 15%. Drought can no more be the fault of a farm than sufficient precipitation can be to its merit. A comparison without meteorological data is irrealistic.

In the meteorological spring (March, April, May) of 1979 the total amount of precipitation ranged from 33 to 341 mm in Hungary, which was 33—235% of the long-term average. The differences were thus much greater than in the autumn. These differences, in a period when the water requirement of wheat is the highest, cannot be the merit or the fault of the farm either.

The yields of different farms cannot be compared unless not only the soil conditions but the weather was also similar in the year of comparison. An objective comparison of this type may certainly promote the propagation of really good farming methods. It might also help in discovering where and with what methods the yield losses caused by unfavourable weather could be reduced or the effects of favourable weather best utilized.

Unfortunately, the most successful farms make no mention of the weather, while farms with low productivity attribute outstanding yields exclusively to the favourable weather conditions which the farms concerned do not even mention, because they feel that they themselves have done everything possible to obtain large yields. For the failures something undefined, called "objective difficulties", is mostly responsible. If the farms reported what the weather was like when an outstanding yield was produced, farms with similar conditions would probably be more interested in exchanging experiences.

Szalai, Gy.: The wheat yields of farms with better soil and climatic conditions must not be compared with those obtained under poorer conditions. In Hungary the quality of the land is expressed in gold crowns which, though not a perfect system, nevertheless indicates the basic differences. For example, the gold crown value of land in Békés county is 29.7 compared to 21.8 in Szolnok county and only 17.8 for the arable land of Somogy county.

In recent studies on the production of winter barley it has become clear that there is a close correlation between cereal crops and the gold crown values, and that the data can be numerically expressed. At the same time, the trend in the yield average varies from crop to crop, depending on the quality of the land. The yield of winter wheat changes by 50—100 kg per gold crown, over the average of several years. This unambiguously proves that wheat yields can only be compared when grown on land of the same value.

VÉSEI, Á.: The comparison of wheat yields is reasonable on areas with nearly identical soil conditions. Farms with more favourable soil and climatic conditions should produce larger yields. In my opinion, in the case of farms with different soil and climatic conditions the cost and profit per ha should be compared rather than the yield per ha.

ZSIRAI, J.: Categories should be set up according to the soil conditions; I should suggest at least five. The farms would be placed in the different categories on the basis of soil maps, according to the size of the areas suitable, less suitable or completely unsuitable for wheat growing, and depending on whether wheat was grown on the latter, and if so to what extent, because unfavourable conditions detract a great deal from the yields of good areas.

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PÁL, GY.: **From the point of view of wheat growing Hungary is divided into regional units suitable, less suitable and unsuitable for wheat growing. Farms are found, however, in all three regional units. Do you think that the yields of wheat grown on areas unsuitable for wheat growing due to administrative measures or out of necessity can be compared with wheat yields obtained on areas suitable or somewhat less suitable for wheat growing when evaluating the wheat production?**

ABONYI-PALOTÁS, J.: In my opinion when evaluating the wheat production of Hungary the yields of wheat grown on areas definitely unsuitable for wheat growing cannot be compared with those obtained on areas more or less suitable for this purpose.

ÁCS, A.: Wheat must be grown in Hungary on more than just the most highly productive areas, since the volume of yield obtained from these areas would not cover the requirements, however high the yield average might be. Wheat must also be grown in regional units and on soil types less suitable for the crop. This should be taken into consideration when comparing the yields of various farms. If the same amount of yield is produced on areas with less favourable soil conditions this suggests that some other agrotechnical factor (precrop, fertilizer, variety, sowing time, etc.) was optimized, thus compensating for the disadvantage caused by adverse natural conditions. Another reason why the total wheat requirement cannot be produced on the best quality land is that these areas are the most favourable for other important crops, too (e.g. sugarbeet, maize, alfalfa, peas, etc.).

BALLA, L.: In this case the yields cannot be compared.

BAUER, F.: Until a uniform system is introduced for judging soil quality I do not see any realistic possibility of comparing wheat production under unfavourable conditions with that on good soils unless evaluation by gold crown value is regarded as such.

BEKE, F.: The yields cannot be compared.

BOCZ, E.: In the future wheat yields should be compared in categories set up according to the soil conditions. If objective correlations are to be established and the merits of farm managers judged, the influence of the crop year on the yield must be precisely determined, so that the professional level of farms with nearly identical natural conditions can also be evaluated.

BODNÁR, M.: In the national evaluation of wheat yields, those obtained on arable areas totally unsuitable for wheat growing should be separately recorded and analysed, as they would unjustifiably lower the wheat yield averages, and Hungary would also be at an unfounded and unnecessary disadvantage in international comparisons. In fact, the separate registration and evaluation of wheat yields obtained on areas unsuitable for wheat growing would hardly affect the standard of wheat production in Hungary, since the proportion of such areas is negligible. Apart from this category, I think the wheat yields in Hungary can be compared over a wide range.

FRENYÓ, V.: There will be a great difference in value if biological production is carried out on a less suitable area at enormous cost without any compelling reason (e.g. war, famine, etc.) for doing so. Yields produced on unsuitable areas obviously cannot be compared to those obtained on areas suitable for wheat growing. At most, such comparative trials may be used to determine the extent to which a shift in the cost-profit ratio can be tolerated.

KÁDÁR, B.: The yield per unit area, and the costs and profitability of wheat production naturally vary from region to region. It might thus be justified to make comparisons within the growing regions.

KISS, Á.: Unfortunately, the yields of wheat grown on areas unsuitable for wheat production must be compared with wheat yields obtained in optimum wheat-growing regions. However, the experts employed by the farms should use the yield data (empirical or experimental) accumulated over a number of years to decide what kind of bread or fodder grain (e.g. rye, winter or spring barley, etc.) should be substituted for wheat in their respective farms.

Although wheat is one of the most easily adaptable plants, under certain extreme conditions, e.g. on sandy soils, where rye gives better yields than wheat, wheat production should not be forced. In particularly rainy years, however, even wheat finds sufficient soil moisture and air humidity at these sites, and produces larger yields than rye. In rainy years rye displays overabundant growth, its stalk often reaches a height of 180—200 cm, and by the time the grains are ripe for harvesting the straw is flat on the ground and looks as if it had been steamrollered. A semi-dwarf strong-strawed intensive rye variety would perhaps solve the problem, in which case the kind of grain crop best adapted to the conditions would be grown on unfavourable sites and wheat production would not be forced. In Hungary 6—8% of the wheat is grown on low-lying areas where it produces almost nothing if there is a lot of water, while it gives a satisfactory yield in a drought. The good yield is included in the evaluation while the water damage is written off as a loss. Wheat growing is greatly influenced by the cultural practices, the precrop, the sowing date, etc. Unfortunately, good and bad cultural practices cannot be separated when making a comparison, and it often happens that on areas unsuitable for wheat production there are 50—100% differences in wheat yield between adjacent farms. It is therefore advisable for the farms to carry out comparative trials, record the major data in their field registers and, above all, listen to the opinions of wheat breeders and experts on wheat production.

KOVÁCS, I.: The authorities do not use administrative measures to force a farm to produce or not to produce wheat. It is up to the farm management to decide this, whatever the conditions of the area concerned are. Nevertheless, experience shows that on areas unsuitable for wheat growing, e.g. on sandy soils poor in organic matter, farms do not produce wheat. For the purpose of evaluation, however, areas suitable or less suitable for wheat production can be compared. The fact that the specific profit will be lower owing to the differential land rent is a different matter. At the same time, it should be noted that winter wheat production is profitable even on farms in Nógrád and Szabolcs counties.

LELLEY, J.: The classification of regions as suitable or less suitable for wheat growing was based primarily on the soil conditions, since the climate is suitable for wheat production almost everywhere in Hungary. Since skilful fertilization and mechanized soil cultivation reduce the importance of the chemical and physical properties of the soil, a comparative evaluation of the wheat yields in different regions may be justified. I am convinced that a yield comparison complemented by authentic economic calculations may also give information as to whether or not the regional classification is correct.

NÉMETH, S.: If the aim of the evaluation is to determine the ecological effects, the comparison is justified.

Pásztor, K.: Wheat yields obtained on areas unsuitable for wheat growing cannot be compared to those produced on the best wheat soils. This sort of comparison would at most give information about what types of soil could be considered suitable or unsuitable for profitable wheat production.

Szalai, Gy.: Dividing the area of Hungary into three regional units is not detailed enough. Even in Borsod-Abaúj-Zemplén, a county in the northern region where the site conditions are generally unfavourable, farms with good conditions can be found, while alkali soils which exercise a harmful effect of the yield occur in Békés, a county where the land is generally fertile. The three regions usually considered (Transdanubia, Great Plain, Northern Hungary) are more indicative of the climatic conditions. The less extreme, rainier climate of Transdanubia is well known in this respect. The wide daily fluctuation of temperature experienced in the second half of February 1980, for instance, caused substantially more damage in Northern Hungary than in other parts of the country. The varying amount of damage was clearly indicated by the different colours of the crops. For 12 days daily temperatures of 6—12 °C alternated with surface frosts of —4—11 °C at night in the northern part of the country.

Vései, Á.: Compulsory production does not exist. The site conditions, particularly the topographic features and the climatic factors, decisively affect the character and proportion of agricultural production. The yields of wheat grown on areas suitable, less suitable or unsuitable for wheat production can only be compared if the cost-profit ratios are taken into consideration.

Zsirai, J.: For the purpose of evaluating wheat production, I think that only farms with identical conditions should be compared for yield. The most important factors to consider are the amount of precipitation in the regional unit or on the individual farms during the growth season, and the size of the irrigated area in the farm, because these circumstances have a decisive influence on the wheat yield.

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Pál, Gy.: **In Hungary wheat varieties are divided into two groups: bread wheats and fodder wheats. The flour from bread wheats is suitable for dough-making by itself, while that produced from fodder wheats is only suitable after mixing with other flours. However, the yield averages of fodder wheats are generally higher than those of bread wheats. When evaluating the farms for wheat production is it, in your opinion, possible to compare farms growing fodder wheats with those producing bread wheats?**

Abonyi-Palotás, J.: I do not consider the yield of bread wheat to be comparable with that of fodder wheat.

Ács, A.: The so-called fodder wheats are undoubtedly superior to the bread wheats as regards potential productivity. Most farms grow both types. The comparison must, in my opinion, be made separately; farms producing the two types of wheat on areas of the same order of magnitude can be compared to each other.

Balla, L.: Most farms produce both bread and fodder wheats. Exceptions are those which produce "only" fodder wheats in some years. But the ratio of the two types varies from farm to farm.

National variety trials have not confirmed the higher productivity of fodder wheats. If in certain plots the fodder wheats nevertheless gave larger yields, this happened for different reasons. There was a period when the standability of fodder wheats was better, so that lodging caused only minor or no losses and they therefore seemed to be more productive. The yield potential of the bread wheats certified in recent years is by no means lower than that of fodder wheats. There must be some other explanation if this yield potential has not yet been achieved in the farms. The recently developed wheat production technology is more favourable for fodder wheat than for bread wheat. If each variety were grown with the right technology there would be no difference in yield between bread and fodder wheats.

At present four varieties are qualified as fodder wheat in Hungary. Of these, the French variety Rivoli does not occupy a significant area. The yield level of the Yugoslav Sava in the national variety trials is the same as that of the bread quality wheat Martonvásári 4, and its yield is declining from year to year. The variety GK Szeged has not become wide-spread yet. The largest area is sown with Libellula, which now gives significantly lower yields than the standard Martonvásári 4, and is becoming worse and worse every year.

If farms produce bread and fodder wheats under uniform conditions and on areas of similar size, their yields can be compared. However, the conditions are not generally identical.

In making a comparison the prices in the different categories must be taken into consideration. In Hungary 7% more is paid for milling (bread) wheats and 14% more for high quality wheats than for fodder wheats. If the latter yielded 7—14% more than the two types of bread wheats, farms producing fodder wheats would obtain the same income. The milling and baking industries would lose, however, due to the lower output of flour and bread. And the consumer would be the real loser, who would have to be satisfied with the poor quality bread made from fodder wheat. Therefore, a comparison of the yields of fodder and bread wheats must be carried out in a complex manner, with consumer interests given due consideration.

Bauer, F.: Yields of farms producing bread and fodder wheats can be safely compared if the prices of the different crops are taken into consideration.

Beke, F.: If quality standards are applied or increased farms producing fodder wheat cannot be compared with those producing bread wheats, or be given the same financial or moral recognition.

Bocz, E.: It follows from what has been said earlier that the method of yield analysis applied at present is too simple, and should be replaced by a new method.

When establishing the annual national yield average no consideration can be given to what the farming conditions were and what varieties were grown.

The method of yield analysis, on the other hand, is determined by the aim of the analysis. If the efficiency of the individual farms and how they compare to each other are to be determined, bread and fodder wheats must be considered separately.

Bodnár, M.: I am of the opinion that the average yields of farms growing fodder wheats can be compared with those producing bread wheats, since almost all the growing conditions and the factors influencing the yield (site conditions, agrotechnics, degree of mechanization, etc.) are identical, the only difference being in the variety grown. In fact, there is no fundamental difference between bread and fodder wheat varieties, since they are both intensive varieties showing no substantial difference in yield potential.

Ecsedi, J.: There are innumerable ways in which comparison can be used as a method of analysis. It is a basic requirement in each case, however, that the things or phenomena compared should be of an identical or at least similar nature. The two groups of wheat varieties are marked by different qualities and offer different biological and economic (e.g. export) possibilities. I think, therefore, that when evaluating wheat yields, and particularly when making a detailed analysis of wheat production, it is better to consider the two variety groups separately. This means, however, that their qualitative characters should be more clearly defined.

Frenyó, V.: Bread and fodder wheats serve different purposes. They differ both in biological character and in utilization value. Naturally, it is advisable to compare the yields within the variety group. If need be, however, the cost of improving the fodder wheats could be added to the cheaper production costs per unit area, and the economic efficiency of using them for manufacturing farinaceous products could be considered.

Kádár, B.: In my opinion bread and fodder wheats must be evaluated separately. But to this end the necessary financial incentives must also be provided.

Kiss, Á.: Farms producing both bread and fodder wheats must be compared for yield. Although fodder wheats generally give larger yields than bread wheats, their monetary value is not necessarily higher. The current intensive bread wheats are high-yielding, and if the premium paid for quality, however modest it is, is added to this, it is almost certain that in places where the ecological conditions are suitable for growing quality wheat the latter should be given preference. On poor to medium sandy soils where the standard required for the baking and milling industries cannot be reached even with quality wheat varieties, fodder wheats should be grown. Despite their low gluten content and poor quality they can supply a fodder crop rich in protein.

Kiss, E.: In Fejér county 74% of the wheat area was sown to bread wheat and 26% to fodder wheat in 1979. Owing to meteorological factors unfavourable for wheat growing, the sowing area of fodder wheats (Mediterranean wheats) has been considerably reduced in 1980. This year 88.7% of the county's wheat area is sown with bread wheat and 11.3% with fodder wheat.

The reduction in the production area of fodder wheats is related with an increase in the area of new spring barley varieties. The new Czechoslovakian and East German spring barley varieties (Triumph, Favorit, Rapid, etc.) can be reliably grown and equal the yield averages of fodder wheats.

The flour quality of fodder wheat is a function of the weather and the crop year. According to the results of quality tests, in 1979 the baking quality of the varieties Libellula and Sava in Fejér county was B_1-B_2.

The proportion of fodder wheats in the total wheat area will continue to decrease, so I do not think an evaluation on the basis of this parameter is realistic.

Kovács, I.: An objective method of purchasing wheat on the basis of quality has been introduced in Hungary as of 1980. The new wheat standard and the closely related price system place wheat crops in three categories. Accordingly, a distinction is made between high quality wheats of baking quality A_1 and A_2, average milling wheats of baking quality B_1 and B_2 and fodder wheats of baking quality C. The prices range from 280 to 320 Ft/100 kg according to the quality categories.

It is true that the yield potential of wheat varieties supplying wheat of fodder quality is generally 15—20% higher. For this very reason it must be decided primarily at farm level what varieties should be grown and in what proportions in order to obtain the highest possible profit. Owing to the different yield potential and the differential purchase price the fodder wheat yields of one farm cannot be realistically compared with the quality wheat yields of another farm. However, with a view to the maximum possible profit, yields must be compared at farm level.

Láng, B.: Now that higher prices are paid for quality wheats yield comparisons between bread and fodder wheats will no longer be a problem.

Lelley, J.: A comparative evaluation complemented with economic data may be justified even between farms producing bread and fodder wheats. Such a comparison may show which category of wheat varieties can be grown really economically in the farm in question.

Németh, S.: There are differences between fodder wheats and bread wheats with regard to both the purpose of production and the general yield potential. This must be taken into consideration when comparing farms for wheat yield.

Nyéki, J.: At an advanced stage of economic development the importance of quality receives greater emphasis.

The proglem is complicated by the fact that not only do the quality requirements to be met by the products change, but the processing technology too. It is always easier to change the technology than to improve the genetic characters.

During the present technical revolution milling and baking technologies have been evolved which make it possible to make good quality bread from flours of inferior quality. I am not sufficiently well informed on this subject to decide which would be cheaper: to improve the genetic properties to the limits of possibility or to refine the present highly developed milling and baking technologies.

It is indisputable that in the course of development the production of wheats which equal or even excel, for example, the outstanding wheats of the Tisza region will gain in importance. In this case the price policy will have to be changed so as to make the profitability of growing wheats with lower productivity but high quality unquestionable.

Pásztor, K.: If information is required about the efficiency of wheat production farms producing fodder wheat must not be compared with those growing bread wheat, as this would lead to erroneous conclusions. The yields of fodder wheats and quality wheats must be evaluated separately. The requirements to be met by quality wheats are different from those to be met by fodder wheats.

PLETSER, J.: Only wheats of the same variety should be compared for yield. This would show what variety could be grown most profitably in each regional unit. The current practice encourages farms to grow fodder wheats, which means that group interests are placed above those of society as a whole.

SZEDERKÉNYI, E.: In the years examined the yield trend was greatly influenced by a change in the wheat varieties in commercial production, because the yield potential and genetically based quality of a variety determine the effectiveness of the other production factors, as well as the quality and baking value of the crop.

In the first half of the seventies the change in varieties accelerated. Owing to their higher productivity fodder wheats occupied an increasing proportion of the wheat area. The percentage of fodder wheats in the total wheat area was:

	1976	1977
Co-operative farms	21.0	29.0
State farms	35.7	44.4
Total	23.4	31.3

The proportion of fodder wheat production is particularly large in state farms with intensive management conditions.

Looking at the proportions of bread and fodder wheats grown in the major regional units of Hungary, it is found that in regions traditionally producing high quality wheat the area of fodder wheat has grown remarkably. In 1977 the proportion of fodder wheats was 43.4% in the region east of the river Tisza and 36.8% in the Mezőföld. Hence, although only about half of the wheat crop is used for human consumption and export purposes, the fulfilment of quality requirements caused problems, mainly because of the proportions and regional distribution of the varieties.

The increase in the proportion of the fodder wheat area, which varied somewhat from region to region, promoted a rise in the yield averages; the average yield of fodder wheats exceeded that of bread wheats by more than 17% in 1976 and 1977 alike (Table 2).

On the other hand, this increase impaired the baking quality of the wheat crop; since the varieties were mixed to a considerable extent, the proportion of fodder wheat mixed in the bread wheat amounted to 20—30%. Fodder wheat varieties reduce the baking value of bread wheats even when some of their quality indices show a favourable trend. In 1978, for example, some 60% of the fodder wheat crop met the bread wheat requirements as regards wet gluten content, gluten elasticity and valorigraphic value, yet the poor gluten quality made it unsuitable for baking purposes.

In 1976 and 1977 the composition of bread wheat varieties also changed. The proportions shifted in favour of varieties with higher productivity. By 1977 the areas of Bezostaya 1, Kavkaz and Avrora had been sharply reduced. The variety Jubileinaya 50 was grown on the largest area, though the areas sown to Szeged (GK) and Martonvás4r (Mv) varieties also grew. The new extremely high-yielding bread wheat, varieties of Yugoslav origin were also grown on a larger area (Partizanka, NS. Rana 1, NS. Rana 2, NS. Rana 3). Although the variety GK Tiszatáj proved very good in farm-scale trials it was inferior in productivity to the best of the new varieties.

The changes which have taken place in the composition of bread wheat varieties may improve the quality of the wheat, as the baking quality of the new varieties is better than that of the older varieties. Exceptions are the poorer quality NS. Rana varieties, which have a baking quality similar to that of Kavkaz and Avrora. Varieties of extremely good quality are GK Tiszatáj, Partizanka and the new Martonvásár varieties.

Table 2

Yield averages of bread and fodder wheats in the different regional units
(ton/ha)

	Co-operative farms			State farms			Total large farms		
	bread wheat	fodder wheat	total	bread wheat	fodder wheat	total	bread wheat	fodder wheat	total
1976									
I. Kisalföld	3.93	4.18	3.96	4.16	4.42	4.22	3.96	4.24	3.99
II Transdanubian hill-country	3.64	4.15	3.78	3.99	4.72	4.32	3.68	4.27	3.86
III. Mezőföld and Danube valley	4.41	5.04	4.58	4.67	5.37	4.93	4.46	5.13	4.66
IV. Hungarian Central Hills	3.28	3.58	3.33	3.85	4.40	4.03	3.38	3.62	3.47
V. Danube—Tisza mid-region	3.74	4.34	3.86	3.83	4.00	3.92	3.75	4.25	3.87
VI. Tiszántúl	3.81	4.40	3.95	3.83	4.38	4.04	3.81	4.40	3.96
VII. Nyírség	2.97	3.94	3.01	4.17	4.75	4.20	3.09	4.04	3.13
Average	3.74	4.37	3.84	4.05	4.60	4.25	3.78	4.43	3.93
1977									
I. Kisalföld	3.83	4.07	3.90	4.33	4.03	4.19	3.89	4.06	3.94
II. Transdanubian hill-country	3.65	3.98	3.76	4.00	4.41	4.21	3.69	4.06	3.82
III. Mezőföld and Danube valley	4.54	5.09	4.74	5.03	5.47	5.23	4.61	5.17	4.83
IV. Hungarian Central Hills	3.38	3.81	3.47	3.73	4.21	3.92	3.43	3.92	3.55
V. Danube—Tisza mid-region	3.90	4.31	4.03	3.97	4.38	4.15	3.91	4.32	4.04
VI. Tiszántúl	4.09	4.84	4.33	4.15	4.73	4.41	4.10	4.82	4.34
VII. Nyírség	3.07	4.18	3.13	3.59	4.53	3.66	3.10	4.21	3.16
Average	3.86	4.54	4.05	4.20	4.67	4.41	3.90	4.57	4.11

VÉSEI, Á.: The comparison is justified if it only considers the yield, not the quality, as it is not a matter of indifference how much flour suitable for making farinaceous products is obtained from the yield of 1 ha wheat.

ZSIRAI, J.: In evaluating the farms the ratio of bread to fodder wheat should be taken into consideration, because farms producing fodder wheat on large areas have an advantage over those growing bread wheats. Higher yield averages can be attained with fodder wheats under the same farming conditions, so a joint evaluation is not acceptable.

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PÁL, GY.: **In the present price of wheat in Hungary the baking quality finds little if any expression; although the standard stipulates a hl-weight of 77—79 kg, 98% purity and 14.5% water content, wheats with a hl-weight of over 73 kg are considered as bread**

wheats. During the evaluation of wheat production in the different farms do you think that the wheat yields of farms growing quality or non-quality wheats, within the category of bread wheats, on areas suitable for wheat production, can be compared?

ABONYI-PALOTÁS, J.: I think that on areas suitable for wheat growing farms producing quality and non-quality bread wheats can be safely compared for the purpose of evaluating the standard of wheat production. This opinion is supported by the fact that Hungary, like many other countries, is attempting to obtain an ever increasing volume of marketable products from an ever decreasing area of land. And this raises the question of the maximum utilization of site conditions and the need to increase farming efficiency. Therefore, when deciding on what variety of bread wheat should be grown the most important thing, in my opinion, is to choose the one best adapted to the local conditions (producing the largest yield). Thus, when examining the 1979 wheat yields, for example, it can be concluded that if the risk is to be reduced greater attention should be paid to resistance when determining the variety structure for the next few years.

In addition to these general considerations, co-operative farms in Csongrád. county will be paying increased attention to quality when evaluating varieties in future. This will also be taken into consideration, together with the yield potential, when fixing the proportions of the varieties to be grown.

ÁCS, A.: Within the bread wheat category, farms producing quality and non-quality wheats can be compared. Differences in hl weight, for example, may be due to the wheat being over-ripe at harvest, or to repeated rainfalls while the ripe wheat is still in the field. This factor reduces the yield average per unit area, but it is practically impossible to eliminate it when comparing wheat-producing farms. Under the same ecological conditions the hl-weight of a given wheat variety should be more or less constant. Soil and weather are the main ecological factors which have a differentiating effect.

BALLA, L.: The yields can be compared.

BAUER, F.: The yields of quality and non-quality wheats can be compared provided the quality bonus is taken into consideration.

BEKE, F.: In regions where good quality wheat is regularly grown the extensive production of fodder wheat is harmful to the national economy. (An example of this is the 1978—79 shortage of quality flour in the quality wheat region on the Great Plain and the problems consequently caused to the baking industry.) From the point of view of exports the importance of this will steadily increase, and this may not be compensated for by a surplus of fodder wheat. In fact, even the domestic requirements may remain unsatisfied.

BOCZ, E.: A detailed analysis of quality for use in determining prices is not something to be aimed at in the future, but a problem which needs immediate attention. Besides quantity, quality is beginning to gain importance. I myself am of the opinion that stricter distinctions should be made between the categories of quality. In the future bonuses for quality will be determined on the basis of flour quality rather than on the hl-weight. This method of classification usually involves the need for higher hl-weight as well.

When comparing different farms, however, the quality of the wheat can hardly be regarded as the merit of the farm. Besides the soil conditions wheat quality depends mainly on the year. Even under the same soil conditions the quality of the wheat may vary considerably from year to year. A method has been elaborated whereby the prospective quality of the wheat can be determined in advance by the end of June, well before the harvest. Such methods mean that the farms can not only make due preparations for the harvest and delivery of the crop, but can also quantify the influence of the weather on crop quality.

BODNÁR, M.: The hectolitre weight and other characters determining the baking quality are influenced by the variety and by natural factors (mainly by the weather), so an improvement in these characters can best be achieved by encouraging a sensible choice of variety. The national variety policy would be improved if the purchase price of wheat were differentiated according to grain quality in addition to the general standards.

This seems to have been partly taken into consideration by the authorities: in the course of a price adjustment in 1980 the extent of the price increase was differentiated by quality. The purchase price for standard bread wheat has been raised by 15 Ft/q and and that for high quality wheat by 30 Ft/q, while the price of fodder wheat has remained unchanged. With a view to improving the standard of wheat production it would be reasonable, when evaluating yields, to treat separately farms whose products cannot be regarded by any objective criteria as quality wheats.

FRENYÓ, V.: In the case of wheat, which is a grain crop of primary importance, emphasis should be laid on quality rather than on quantity. Attention should also be paid to foreign markets, where the demand is very sensitive to quality. It is therefore necessary to elaborate standards of wheat quality which make finer distinctions possible, and at the same time a definite preference should be given to farms producing quality wheats.

KÁDÁR, B.: The co-operative and state farms will continue to think in terms of yield averages until the quality is properly appreciated in the prices of their products. In the past the wheat yields of the farms could be compared even when they produced wheats of different qualities. In the future, if the quality is expressed in the price, it will probably be more realistic to make a comparison on the basis of per ha returns from sales (i.e. production value) as well as the yield average.

KISS, Á.: To the best of my knowledge a quality index determined on the basis of the hl-weight is not sufficient to establish the value of a bread wheat variety. This is very well known to baking and milling experts. At present there is no better and quicker method of qualification, which is why this standard is applied when buying up wheat. In spite of this, comparison must somehow be made, so the evaluation is permissible.

LELLEY, J.: A comparative evaluation of wheat varieties of good anu outstanding quality, combined with the relevant cost calculations, may be highly instructive provided the fact that high quality wheat may be sold for convertible currencies is taken into consideration.

It should be noted that the wheat quality parameters mentioned in the question are totally unsuitable for classifying wheats according to baking quality, and still less suitable for pointing out possible differences between them. It would be impossible to introduce a price system based on these parameters that would compensate for the slightly lower genetic yielding potential of outstanding quality wheat varieties. Such differences in quality can be demonstrated with a Farinograph-Resistograph or a Valorigraph, but these instruments are expensive, have a low daily performance, and give more information about the quality than is necessary when buying up. The Pelshenke test is cheap but time-consuming, while Zeleny's sedimentation test is simple, quick and very reliable and the instruments are cheap, so this method is many times more efficient than the other methods mentioned. With this procedure the baking quality of wheat lots could be rapidly and reliably established at all purchasing stations.

MOLNÁR, F.: In the current price of wheat in Hungary the baking quality is not sufficiently expressed. At present the purchasing authorities do not possess instruments with which the quality of the crop delivered by the farms could be satisfactorily established. According to the latest information, the new purchasing system again classifies wheats primarily according to the variety. In some cases spot checks are performed. In order to evaluate wheat production, a realistic comparison can only be made between farms which grow the same range of varieties.

NÉMETH, S.: Farms growing quality and non-quality wheats should not be compared for yield, despite the fact that the yields of quality wheats are not always lower. In 1979, for example, the quality wheat varieties GK Tiszatáj, Mv 4 and Jubileinaya yielded 7.0—7.2, 7.3—7.9 and 7.4—7.8 tons/ha respectively, while the non-quality varieties N. Rana-2 and GK Szegedi yielded 6.7—6.9 and 5.9—6.1 tons/ha respectively in irrigated trials. In the non-irrigated variety trial the yields of quality and non-quality wheats showed the same order. Substantial differences were found in the flour extraction percentage in favour of the quality wheats, which gave 73—75% of A and B quality flours, while certain non-quality (fodder) wheats gave only 60% of C quality flour. Unfortunately, the quality is not expressed in the purchase price. In wheat variety policies greater attention should be paid to these aspects. I should like to add that in our experience "quality" wheats are superior to "non-quality" wheats as regards winter hardiness.

PÁSZTOR, K.: The average wheat yields of farms producing quality wheat ought not to be compared with those obtained in farms growing mostly fodder wheat, because such a comparison may lead to incorrect conclusions. The hl-weight was earlier taken into consideration mainly with the aspects of milling in view. According to the results of recent investigations the hl-weight does not give sufficient information on the baking quality of the flour obtained from the wheat. Now that quality requirements have come into prominence and prices are fixed on the basis of quality it is becoming more and more important for analytical instruments to be used when grain crops are bought up. The question of quality wheats must be settled as soon as possible and bread wheats must be handled separately from fodder wheats.

PLETSER, J.: Baking quality depends mainly on the variety grown, though the agrotechnical methods and the weather also have some influence on it. When comparing yields not only the quantity of yield but also the baking quality of the variety should be reported. It often happens that the baking quality is not determined until after the wheat has been purchased, and varieties originally grown separately are mixed. The price difference does not encourage the producer to protect the quality obtained.

SZEDERKÉNYI, E.: The wheat production of Hungary has recently shown dynamic progress and yield averages have increased to a considerable extent. However, parallel with the rising yields the quality has not even been maintained at the previous level. Since the early seventies the baking quality of the wheat has worsened to such an extent that this cannot be explained by a change in the weather from year to year. At the same time, the quality requirements for cereal products are constantly increasing. High quality bread wheats sell better on foreign markets too. A sensitive price system taking the volume and quality of the crop into consideration and thus ensuring an equilibrium between consumers' demands and the farmers' interests should therefore be introduced.

In the course of investigations on this subject hardly any farms were found to produce exclusively bread or fodder wheat. Generally they grew both types, though in varying proportions. There were practically no farms that produced only high quality wheat. So I think that if the variety structure and the yields are known the wheat production of the farms can be evaluated and compared; the comparison of varieties and variety groups also provides an opportunity to draw useful conclusions. For the cost and profitability calculations publications from the statistics department of the Ministry of Agriculture and Food were used. "Quality charts" produced by the Quality

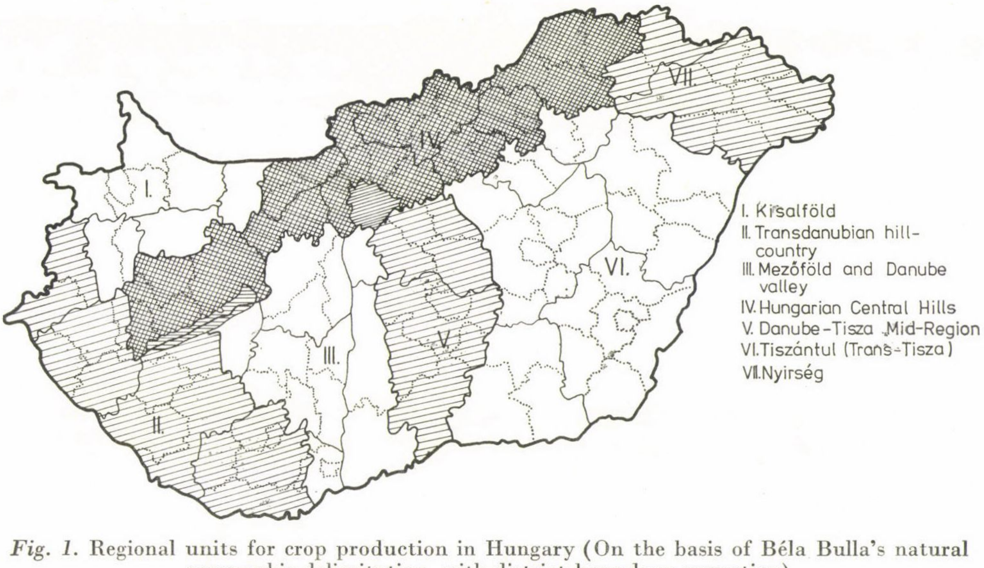

Fig. 1. Regional units for crop production in Hungary (On the basis of Béla Bulla's natural geographic delimitation, with district boundary correction)

Testing Section of the Cereal Trust, the experience gained when buying up wheat according to grain quality in 1978, and analyses by the Cereal Research Institute, Szeged, and the National Institute for Agricultural Variety Testing formed the basis for the evaluation of changes in the quality of the wheat. The major crop production regions (Fig. 1) were established using Béla Bulla's natural geographic distribution with a district boundary correction.

The growing site influences both the quantity and quality of yield.

The major natural factors which determine the quantity are the soil, topographic and climatic conditions, but these can be more or less counterbalanced by human intervention. The growing site has a greater effect on the quality, as shown by trends in the major qualitative indices of wheat in the different regional units (Table 3).

The entire area of Hungary is suitable for the production of wheat whose quality meets the requirements of the baking industry. The quality improving effect of the growing site should be made use of mainly in growing high quality bread wheat. The Tiszántúl (the region east of the river Tisza) is the most suitable for this purpose, though wheat with excellent baking quality can be obtained from certain parts of the Mezőföld and the Danube valley and also from the Nyírség.

A fully mechanized technology for wheat production was developed some time ago; in recent years only an improvement in the farming methods has taken place.

Of all the agrotechnical elements, the greatest change observed during the years examined occurred in the method of fertilization. In co-operative farms the volume of fertilizer active agent used for wheat production in 1976 and 1977 rose enormously

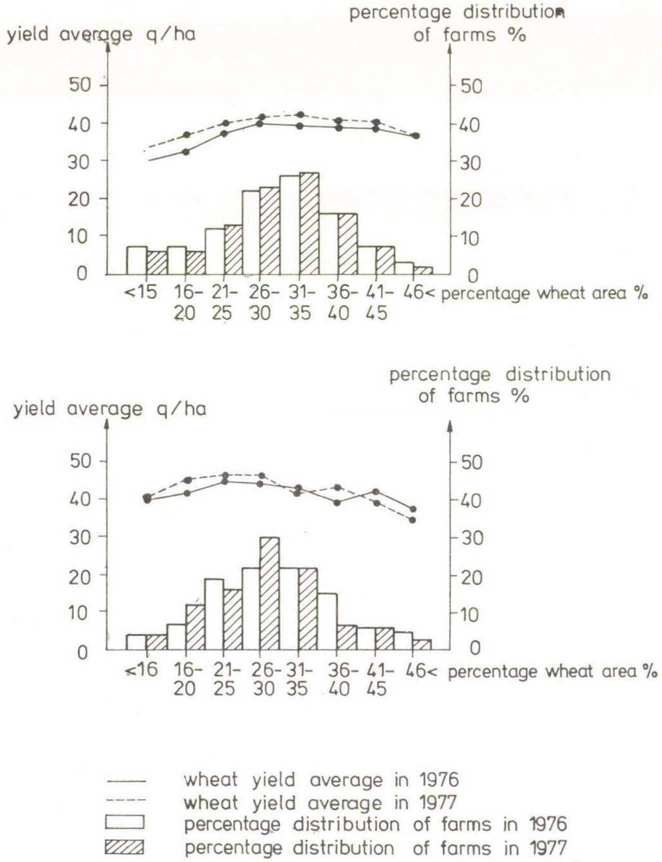

Fig. 2

Table 3

Quality indices for bread wheat bought up in 1978 in the different regional units

	Wet gluten content, %	Gluten elasticity, mm	Percentage distribution by valorigraphic value groups %			
			A_2	B_1	B_2	C_1
Kisalföld	33.7	7.5	1.8	98.1	0.1	—
Transdanubian hill-country	30.0	5.3	1.7	62.1	34.8	1.5
Mezőföld and Danube valley	30.5	5.3	9.9	56.9	27.6	5.6
Hungarian Central Hills	33.8	6.3	0.2	66.0	31.5	2.3
Danube—Tisza Mid-Region	33.2	6.8	2.7	52.1	44.4	0.8
Tiszántúl	30.4	3.8	11.8	66.2	20.5	1.5
Nyírség	31.5	3.9	1.1	92.2	4.3	2.4
Average	31.6	4.9	6.8	64.7	26.3	2.2

Based on the results of objective analyses of GT.

Table 4

Amount of fertilizer used for large-scale wheat production

	Co-operative farms			State farms		
	1975	1976	1977	1975	1976	1977
Yield average, ton/ha	3.15	3.84	4.06	3.61	4.25	4.41
Fertilizer active agent, kg/ha						
N	116	129	134	136	129	130
P_2O_5	47	86	97	104	98	99
K_2O	49	88	102	110	106	109
Total	212	303	333	350	333	338
Fertilizer active agent used for 1 ton yield, kg	0.67	0.79	0.82	0.97	0.78	0.77

compared to the previous years and reached the fertilization level of the state farms. In addition, the ratio of nutrients changed in both types of farms; the quantity of nitrogen active agent decreased and the amounts of phosphorus and potassium increased. The favourable nutrient supply helped the varieties to fulfil their yield potentials, while also restoring the nutrient level of the soil. A further increase in the rate of fertilization without a change in the other production conditions is not advisable, because in 1977 the efficiency of fertilization was already lower than in 1976 in spite of the increasing yield averages (Table 4).

According to the investigations of Láng and Austin [G. Láng (1978): Az agrotechnika hatása a kenyérgabona minőségére (Effect of cultural practices on the quality

Table 5

Fertilizer utilization according to variety groups in the large-scale farms

	1976			1977		
	yield average t/ha	fertilizer utilization		yield average t/ha	fertilizer utilization	
		kg/ha	kg/t		kg/ha	kg/t
Co-operative farms						
bread wheat	3.74	298	80	3.86	329	85
fodder wheat	4.37	322	75	4.54	344	75
State farms						
bread wheat	4.05	333	82	4.20	333	79
fodder wheat	4.60	333	72	4.67	344	74

of bread grains). Gabonaipar XXV, 6; A. AUSTIN (1978): Improvement of wheat quality. Indian Farming, February], fertilization also has an impact on the quality of the wheat. An adequate supply of nutrients is indispensable if the potential baking quality of the variety is to be achieved. As a response to nitrogen fertilization the protein content of the crop increases, but its amino acid composition becomes less favourable. The baking quality can only be improved within the genetically determined limits even by fertilization.

No decisive difference in yield due to the rate of fertilization can be seen in the individual variety groups (Table 5).

The amount of fertilizer used in fodder what production was slightly larger both years, so no great importance can be attached to it from the point of view of yield formation. In consequence of the higher productivity and larger actual yield of fodder wheat the efficiency of fertilization was better in this variety group, in spite of the higher rate of fertilization.

VÉSEI, Á.: I think the question is wrongly formulated. According to decree No. 18/1979 (IX. 29.) MÉM-ÁH any wheat variety not ranked as a bread wheat is classified as a fodder wheat. In other words, fodder wheat cannot be purchased at bread wheat prices even if the hl-weight is over 74 kg. Consequently, the difference in quality is expressed in the price.

ZSIRAI, J.: I do not think it is realistic to compare the yields of farms growing quality and non-quality bread wheats, because under identical conditions quality wheats give lower yields than non-quality wheats.

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PÁL, GY.: **Maize growing is profitable at above 45 q/ha in well managed farms and at above 50 q/ha in farms with medium productivity, while wheat production is profitable at above 32 q/ha on average. The unit cost of wheat production is about 230 Ft/q in Hungary, so at present wheat production is more profitable than maize production. Is it permissible, in your opinion, to compare the wheat yields of farms producing wheats at different unit costs in order to evaluate wheat production?**

ABONYI-PALOTÁS, J.: I do not think the yields of farms producing wheat at different unit costs should be compared.

It is well known that on areas with different conditions different yields are obtained from the same investments. It is also known that on areas with different conditions the cost level beyond which surplus costs result in lower returns, i.e. extra investments appear as a deficit, is different.

Examination of a series of wheat yield data reveals that with an increase in investments the unit cost and the yield average also increased, but the efficiency of the farm decreased. It should be noted here that wheat is less responsive to extra investments than maize.

The question of how the average gold crown value of the wheat area of co-operative farms in Csongrád county is related to the gold crown value of the total arable area of the co-operative farms in the county has been studied. The result was —36, which means that wheat is not grown on the best soil in the county, keeping in mind the fact that its soil requirement is lower than that of maize or sugar-beet. (It should be noted, however, that on better soils wheat would also give a higher yield average.)

Further, the correlation between the average gold crown value of the wheat area and the unit cost per ha has also been calculated. The result is: $r = -0.430$. This means that on areas with higher gold crown values, wheat can be grown at lower production costs (since the value of r is negative); nevertheless, the looseness of the correlation calls attention to the fact that the quality of the land is not the only factor which determine the costs.

In general the upper cost limit for wheat production cannot be precisely determined, partly because of the important role played by factors beyond human control. (For example, foliar nutrition applied during a drought will increase the tolerance of the plants, but if it does not rain within 4—5 days the increased cost will not result in an increase in yield.)

There is general agreement in professional circles, however, on the positive effect of certain factors on wheat production.

These include up-to-date machinery that makes it possible for sowing and harvesting to be started at the optimum time and completed in 10 days each. (This machinery should include seed-drills which ensure a much more even plant distance than at present, fertilizer distributors of high capacity, producing uniform distribution, and harvesters which can be adjusted to the yield; these are only partly available at present.) The most serious deficiencies, however, are experienced in the field of soil cultivation. Energy-saving methods for retaining the water content of the soil and preparing a satisfactory seed-bed even when the weather conditions are other than average should be elaborated and introduced. In modernizing soil preparation methods the quality of the farm and even of the field in question must be taken into account to a greater extent than at present.

Farms belonging to production systems are known to give better yields than those not associated to a system, due partly to the more favourable conditions and partly to the higher technical level and better technological discipline. It should be noted, however, that the production systems give a general technological framework which has to be adapted to every farm and even to the individual fields, taking the local experience into consideration. Consequently, the maximum permissible value of the various kinds of costs is highly differentiated, and this differentiation varies not only from place to place but also from year to year. The question is made still more complicated by the fact that the balance between the production factors plays a very important role.

ÁCS, A.: This is a question for the economists. The production cost is the difference between total costs and the crop returns. The production cost is high if substantial investments are required to produce a crop of low value. Owing to the different conditions on the farms production costs vary enormously. A well managed farm produces the same average yield at a lower production cost.

In making comparisons the principle of economic efficiency should be taken for a basis. Investments are only justified if they lead to efficient production.

BALLA, L.: For the purpose of evaluating wheat production a yield comparison between farms producing wheat at different unit costs is allowable, but care must be taken to draw the correct conclusions. Such a comparison may be useful when aimed at finding out how to reduce the unit cost of wheat production.

BAUER, F.: As far as the wheat growing competition is concerned the unit cost of producing wheat within the same category of sowing area and soil quality is the internal affair of the farm, and will only be considered when the profitability level of the whole farm is judged.

BEKE, F.: Yield averages and unit production costs do not provide a satisfactory basis for comparisons between farms. The easily cultivated soils and high yield averages of the Bácska table-land (a region in southern Hungary) cannot be compared, for example, with the laboriously cultivated, but highly fertile soils of the Tisza region.

The corresponding data of adjacent farms can be compared, because in this case the optimization conditions can be determined, but this is hardly feasible for regional units which lie far away from one another.

BOCZ, E.: This question is closely related with the more rational use of land, which should be aimed at in the future.

Wheat production basically requires much lower investment than maize production; in addition, a yield level exceeding the lower limit for economical wheat production can be achieved even on poorer soils.

In a more differentiated yield analysis it is important that the standard of professional management in the farm should also be taken into consideration. This is only possible if the yields are expressed numerically, giving a true picture of the situation, as a function of farm activity, soil conditions and crop year. This will enable the differences in yield average caused by the natural conditions and human activity to be demonstrated.

BODNÁR, M.: The unit cost is one of the most comprehensive indices of the efficiency and successfulness of farm production; it tells a great deal about the ratio between the production factors and the way they are utilized. The comparative analysis of farms producing wheat at various unit costs is therefore not only permissible but also fundamentally necessary.

In carrying out a comparative evaluation, as in the case of different quality lands, attention should be paid to farms producing wheat at higher unit costs due to the natural conditions (soil, climate, etc.), since the yield of wheat grown on areas with unfavourable conditions (some 20—25% of the total wheat area in Hungary) is usually less than that achieved on farms with favourable conditions, even if the investments are above-average. Thus, in the course of a comparative analysis corrections should be made accordingly.

However, an overwhelming proportion of the wheat-growing farms in Hungary can be compared for yield without any special difficulty. Comparability is increased by the fact that the agro- and biotechnics of wheat production and the technology required to synthesize and systemize it have been elaborated on the basis of the most recent results of science, technology, farm management and practical experience (change of varieties), and is now generally applied in Hungarian farms. Furthermore, by taking advantage of various forms of horizontal connections a considerable proportion of wheat production is now carried out in "production systems" which ensure the optimum amount and ratio, complexity and synchronization of the production factors. The dymanic development which has taken place in wheat production thus means that whether wheat is grown with or without the help of a production system it is now produced in large-scale farms where the technology applied requires a high level of investment. This undoubtedly makes the comparison easier and at the same time calls attention to the importance of a comparative evaluation. There is, however, a still stronger argument to support the usefulness of a comparative analysis: paradoxically, in wheat and maize production, which show the most intensive and most dynamic development from a biological, technical and scientific point of view, a stagnation or a slow but steady increase in the unit cost has recently been observed, not only in Hungary but internationally. It is therefore very important, at farm and national economy level alike, to improve the cost-profit ratio (i.e. to increase the efficiency of the investments) not only by producing larger yields but also through a rational and economical use of resources. Considerable reserves are available in this respect. From among the numerous instances where an economical level of investment has been attained the results of experiments carried out at the Plant Production Department of the Debrecen University of Agricultural Sciences may be chosen as an example. In the experimental plots a given yield level (5300—5500 kg/ha) was attained over several years with a fertilization rate some 25% lower (otherwise under the same production conditions) than that described in the technology elaborated by the KITE production system for its member farms.

In fact, the profitability level of wheat production is somewhat higher than that mentioned in the question, since in 1977, the year taken as the basis for price adjustments, the national average unit cost level for wheat was put at 205 Ft, which did not change significantly in 1978. In 1979, for well-known reasons, the profitability perceptibly decreased; but, naturally, no far-reaching conclusions can be drawn from the data of a single year, especially when it is an extreme one. It is true, on the other hand, that besides the positive effect of the 1980 price adjustment on the purchase price of wheat (an increase of 150—300 Ft/t) the unit cost of wheat production is also expected to rise by some 350 Ft/t if the price increases for agricultural equipment and chemicals are also taken into consideration.

Ecsedi, J.: The unit cost is an index of efficiency, which in this case shows how and under what conditions the wheat was produced. The unit cost, like the yield, is influenced by many factors. The total investments and the individual costs both have an effect on the unit cost, as does the yield level.

Farms growing wheat under similar ecological conditions are found to produce wheat at highly different unit costs. This can chiefly be explained by differences in the technology or in the way in which it is applied. Therefore, a comparison of the yields of farms with similar site conditions with a view to evaluating farm efficiency is necessary even if they produce wheat at different unit costs. The very aim of this type of analysis is to discover the causes of the differences in yields.

Frenyó, V.: In considering the possibilities of comparison from the point of view of economic efficiency it is necessary to choose a method of evaluation by means of which the unit cost indices can be handled in a complex manner. Besides the natural conditions the unit cost indices are sharply affected by the technological organization and discipline, the degree of mechanization and the level and flexibility of the farm management. All this must also be taken into consideration in a complex evaluation.

Kádár, B.: The agricultural efficiency of a farm cannot be correctly evaluated on the basis of the yield average for a single crop. In fact, I think the profit per unit area or the profit proportionate to the cost are more decisive indices of economic efficiency in any branch of farming within a given farm than the yields. Comparison and competition between the different branches of crop production within a given farm is only realistic on the basis of profitability indices. The cost per production unit is, in my opinion, a secondary index from the point of view of economic considerations. This also applies to wheat. Wheat may provide a varying degree of profit in different farms irrespective of the unit cost; thus, the latter cannot be the criterion of comparison.

Kiss, Á.: Farms producing wheat at different unit costs cannot be compared for evaluation purposes. Hungary is obliged to produce some of its wheat on areas unsuitable for wheat growing. On areas with poor natural conditions a 3000 kg/ha wheat yield is often produced at a higher unit cost than in farms producing wheat under favourable conditions. In the latter case a 5000 kg/ha wheat yield is easier and cheaper to produce, so the comparison is somewhat misleading.

Kiss, E.: The prime cost of wheat production in 1977 was 202 Ft/q on a national scale and 197 Ft/q in Fejér county. In my opinion the comparison of farms on the basis of unit production costs of wheat is not realistic, because the average yield may vary greatly according to the growing conditions. The rapid change in production costs (material and energy price increases) makes the comparison even more difficult.

Kovács, I.: Wheat production cannot be evaluated simply by a comparison of yield averages. The proper evaluation of this branch of agriculture is only feasible on the basis of economic efficiency, by analysing the cost-profit ratio under the given site conditions.

Lelley, J.: In places where wheat production is more economical due to lower costs, full mechanization and a lower manual labour requirement, and where the purchase price is not kept artificially high, the sowing area of wheat can be extended within reasonable limits, provided it does not disrupt the succession of crops and it is justified by other economic considerations. There are, however, biological and managerial aspects which determine the optimum crop ratio. These limits must not be surpassed even if it means a short-term advantage, because in the long run the harmful consequences could not be avoided. Thus, when determining the crop structure the long-term profitability rather than the momentary profit should be kept in view.

NÉMETH, S.: The wheat yields of farms producing wheat at different unit costs can be compared if the comparison is coupled with adequate economic analyses.

NYÉKI, J.: I think it probable that the trend in production costs parallel with the increase in yield plays an ever greater role in deciding which plant species will be cultivated. This may also mean, now that unit costs are lower, that in the regions most suitable for wheat growing the wheat production will increase as long as favourable economic conditions exist (export possibilities, etc.).

The comparison of farms producing wheat at different unit costs would not be realistic, since at national economy level (energy utilization, the implication of energy imports, import of machinery and chemicals, etc.) economic activities with lower unit costs are definitely more valuable. It may happen, of course, that the influence of the unit cost on farm efficiency is pushed into the background, but this is not characteristic of the normal development of the national economy.

Thus, in my opinion farms producing wheat at different unit costs can only be compared in exceptional cases; under normal economic conditions the unit cost has a decisive influence on production and on how it develops, and only an unfavourable trend in the unit costs may force a farm to change its profile.

PÁSZTOR, K.: When wheat yields are compared in order to evaluate the efficiency of wheat production the unit cost must also be taken into consideration. It would be incorrect to judge the profitability of a farm exclusively by the yield. Increased attention should be paid to the final product. At the same time, maize should be grown on good maize areas and wheat on areas favourable for wheat.

SZEDERKÉNYI, E.: In large-scale farms in Hungary the wheat production costs increased fairly evenly between 1971 and 1975. The unit cost per ha of wheat production rose from 7,834 to 8,545 Ft in the state farms and from 4,771 to 6,240 Ft in the co-operative farms (data from the Statistics Centre of the Ministry of Food and Agriculture). There was a considerable difference in the rate at which the costs increased in the two types of farms: it was 2.3% in the state farms and 7.7% in the co-operative farms. This rapid change in the costs was caused by an increase in fertilizer and energy consumption, and, in the co-operative farms, by a rise in overheads too.

Price increases on the world market and an unfavourable trend in the exchange rate made it necessary to economize on imports, to increase farm efficiency, and to reduce state aid to farms. Accordingly, the prices of fertilizers, pesticides and herbicides rose from 1st January 1976. Also, the fuel dotation granted to set off the cost-increasing effects of the 1975 fuel price increase was discontinued, and this also had something to do with the increase in production costs.

By 1976 the production costs had risen by 28% in the co-operative farms and 11% in the state farms compared to the 1974—1975 average (Table 6).

Due to the high degree of mechanization the proportion of wages within the cost structure is very low, and the sum hardly changed during the period examined. The costs of materials and subsidiary enterprises are very high, however, making up more than two-thirds of the production costs in both types of farms. A major proportion of the cost increase that occurred in response to the price changes (64% in the co-operative farms) stemmed from changes in the costs of materials and subsidiary activities. Consequently, farms could most successfully check the rise in costs as a whole by improving the efficiency of financial investments and of the subsidiary activities, and by strictly observing the technology.

Apart from minor fluctuations the cost ratios established in 1976 remained unchanged in 1977 and 1978. Costs continue to rise, though moderately compared to the rate in 1976, mainly due to the rising prices of machinery, spare parts and pesticides, rather than to an increase in investments.

Winter wheat production has dynamically progressed and has become a profitable branch of agriculture. It was in winter wheat production that the most important farming conditions, a balance between biology and technology, first came about. Owing to its profitability and the fact that it makes up a fairly high proportion of the total production, winter wheat provides a considerable part of the profit derived from agricultural activities in the large-scale farms.

Changes in the profitability of wheat production in the large-scale farms are shown by the data in Table 7.

Table 6

Cost structure of wheat production in large-scale farms

	1974—1975 average		1976		1977		1978	
	Ft/ha	%	Ft/ha	%	Ft/ha	%	Ft/ha	%
Co-operative farms								
Cost of materials	2,731	44.2	3,164	40.1	3,416	40.2	3,591	38.8
Wages	224	3.6	243	3.1	222	2.6	233	2.5
Costs of subsidiary enterprises	1,659	26.9	2.253	28.6	2,409	28.3	2,671	28.9
Other costs	344	5.6	447	5.7	545	6.4	730	7.9
Direct costs	4,958	80.3	6,107	77.5	6,592	77.5	7,225	78.1
Overheads	1,218	19.7	1,776	22.5	1,909	22.5	2,025	21.9
Production cost	6,176	100.0	7,883	100.0	8,501	100.0	9,250	100.0
Value of by products	−254		−365		−312		−292	
Production cost of main product	5,922		7,518		8,189		8,958	
State farms								
Cost of materials	3,790	43.4	3,907	40.3	4,153	42.3	4,429	40.6
Wages	286	3.3	318	3.3	303	3.1	286	2.6
Costs of subsidiary enterprises	1,899	21.8	2,554	26.4	2,676	27.2	3,246	29.7
Other costs	369	4.2	495	5.1	410	4.2	540	5.0
Direct costs	6,344	72.7	7,274	75.1	7,542	76.8	8,501	77.9
Overheads	2,388	27.3	2,418	24.9	2,282	23.2	2,417	22.1
Production cost	8,732	100.0	9,692	100.0	9,824	100.0	10,918	100.0
Value of by-products	−228		−444		−404		−363	
Production cost of main product	8,504		9,248		9,420		10,555	

Up to the mid-seventies a steady increase in yields counterbalanced the rising costs, and profitability showed a favourable trend. However, in 1977, despite a 13—19% yield increase compared to the 1974—1975 average the income per ha dropped by 3.3% in the co-operative farms and 4.2% in the state farms. This tendency continued in 1978, when the costs increased at a lower rate than in the previous year, but the profit per ha obtained from wheat production decreased by a further 10—12% in spite of the record yields. Accordingly, the rate of income also became considerably less favourable than in previous years.

Apart from the costs, the development of technology and the introduction of varieties with higher productivity also contributed to the present yield level, and thus to the trend of incomes.

The fact that the purchase price of fodder wheats was raised in 1976 from 2,570 to 2,800 Ft/ton while the price of bread wheat was left unchanged has counteracted the reduction in income. This measure gave a financial incentive to farmers to increase the proportion of fodder wheat production, since the difference in purchase price between bread and fodder wheat is hardly more than 5%, while the yield difference between the bread and fodder wheat varieties commercially produced at present is

Table 7

Profitability of large-scale wheat production

	1974–1975 average	1976	1977	1978
Co-operative farms				
Production cost, Ft/ha	5,922	7,518	8,189	8,958
Production value, Ft/ha	9,085	10,816	11,248	11,698
Income, Ft/ha	3,163	3,298	3,059	2,740
Unit cost, Ft/ton	1,752	1,943	2,032	2,138
Income rate, %	55.4	43.9	37.4	30.6
Yield average, ton/ha	3.38	3.87	4.03	4.19
State farms				
Production cost, Ft/ha	8,504	9,248	9,420	10,555
Production value, Ft/ha	11,290	11,606	12,090	12,908
Income, Ft/ha	2,786	2,358	2,670	2,353
Unit cost, Ft/ton	2,197	2,197	2,156	2,295
Income rate, %	32.8	25.5	28.3	22.3
Yield average, ton/ha	3.87	4.21	4.37	4.60

Table 8

Income from bread and fodder wheat production in the co-operative farms
1976–1977*

	Bread wheat		Fodder wheat	
	1976	1977	1976	1977
Production cost, Ft/ha	7,460	8,098	7,734	8,411
Production value, Ft/ha	11,033	11,387	12,236	12,712
Income, Ft/ha	3,573	3,289	4,502	4,298
Income rate, %	47.9	40.6	50.8	51.0
Yield average, ton/ha	3.74	3.86	4.37	4.57
Purchase price, Ft/ton	2,950		2,800	

* Returns from the sale of the full crop at purchase price.

more than three times as much. Since the production costs of fodder wheat are, in effect, no higher than those of bread wheat, farmers could obtain a higher income by growing fodder wheat even if they sold it at the price fixed for the variety group.

The Hungarian accounting system does not make it possible to separate the production costs and returns of bread wheat and fodder wheat. There is not enough difference in production technology between the two groups of varieties to cause a decisive change in the cost. On the basis of the yield averages quoted above, the differences in fertilizer utilization and the yield-proportionate changes in harvesting and transporting costs, the profitability ratios of the two types of wheat can be calculated. According to our calculations, the returns from bread and fodder wheat production in co-operative farms in 1976 and 1977 showed the trend seen in Table 8.

The returns from fodder wheat production exceed those from bread wheat production by 1000 Ft/ha (26—30%). This was the decisive reason why farms extended the area of fodder wheat production. This tendency acted against the fulfilment of quality requirements.

Since 1st January 1980 the purchase price of wheat has changed. The new purchase price system pays for quality and use-value to a much greater extent than the previous system.

VÉSEI, Á.: The comparison should definitely be made, taking the purpose of production (as feed or to sell) into consideration. The result, i.e. the economic efficiency, should be measured on a cost and profit basis.

ZSIRAI, J.: Since unit costs can be classified and show the standard of management rather well, I should place farms producing wheat at different unit costs in different categories and only compare those within the same category.

*

PÁL, GY.: **By some means or other the yields of wheat-producing farms have to be evaluated and this can only be done if there is something to compare them with. A comparison can only be made, however, between farms growing identical crops under identical conditions. And the human mind is designed to seek and find the truth** *(quid magis desiderat anima quam veritatem? Augustinus)*[1]. **So please express your opinion and present a suggestion as to how you would evaluate and compare the wheat yields of wheat-producing farms.**

ABONYI-PALOTÁS, J.: An evaluation of the yields of wheat-growing farms is no easy matter, as has been seen in the course of this discussion. The difficulty lies mainly in the fact that the yield is the "resultant" of the joint action of a great many factors, and depends on the adequacy of each factor and a balance between them all.

In evaluating wheat yields a distinction must definitely be made between wheat areas with different conditions. If the different soil and climatic conditions were ignored the results would be falsified. What natural index (or indices) or possibly a complex index should be used to characterize areas with different conditions on the basis of quantifiable criteria may be a subject for debate, but its necessity is, in my opinion beyond question. Further production factors to be considered are:

- varieties best adapted to the local conditions,
- soil conservation,
- weed control,
- disease control,
- modern machinery with the correct capacity (ensuring the optimum fulfilment of local demands),
- appropriate professional staff, and finally
- an adequate amount of up-to-date storage facilities.

In my opinion, at the present standard of management the theoretical optimum for these factors is not available in Hungarian farms. Although farming practice is always one step behind the most recent achievements of science, and it also takes time for the latter to become "ripe" for practical application, efforts must be made to come as close as possible to the optimum conditions already applicable in practice. Perhaps the difference between the existing conditions and the optimum (measured in forints or in natural units) would be the best illustration of the efficiency of wheat

[1] What more can the soul desire than the truth? Augustine.

production. Distortions do occur, of course, owing to the influence of factors beyond human control, even when comparing areas with conditions considered identical before production began; such a distortion may be due, for example, to the presence or absence of rain in a critical period.

In contributing these remarks to the conference I hope that wheat production will continue to develop in the future, and that work aimed at a more rational evaluation will succeed in bringing the necessary system of conditions into existence.

ÁCS, A.: I should give the highest qualification to the farm that produced the largest amount of wheat at the lowest production cost. This is clear and self-evident.

I agree with the statement that "comparison can only be made between farms growing identical crops under identical conditions".

There are no two farms that meet these criteria fully, since no two farms have perfectly identical conditions, so in a strict sense it is impossible to compare yields of different farms. Nevertheless, comparisons must be made, keeping in mind the fact that perfect results free of error cannot be attained.

The ecological research currently conducted on a national scale may offer help in this field, too. The distorting effects of certain factors should be screened out. Indices should be established for the different ecological regions. If, for example, the yield obtained on the Hajdúság loess-table, a region east of the river Tisza and one of the best wheat growing regions in Hungary, is taken as 1, the yields of other regions should be multiplied by 1.2—1.4—1.6—2. Other yield factors could perhaps be reduced to a common denominator, to use a mathematical analogy. After this the human factor, professional ability, can be compared to the yields and evaluated, but even then not with absolute reliability.

BALLA, L.: At national level the aim of wheat growing is to produce the bread grain required to feed the population (and for other purposes). At farm level the economic efficiency of wheat production, giving the highest possible income, is the most important viewpoint. The economic efficiency is fundamentally determined by the yield, the technological system, the costs (fertilizer, chemicals, seed, etc.) and a balance between the factors influencing cost and profit.

The average yield has a decisive role in determining the economic efficiency. If the yield is higher the production costs increase, but this increase is less than the surplus income obtained from the larger yield, so the specific income rises. The unit cost of 100 kg grain yield is a very important factor in this.

It follows from the above that a yield comparison between wheat growing farms is feasible by means of complex economic calculations in which the yield per ha is only one of many factors. The present task is to determine the optimum (most profitable) level for the average yields. This will probably be different under favourable and unfavourable farming conditions. Above a certain yield level further investments will not be economical anywhere.

The wheat production of farms can thus be compared and evaluated on the basis of yield, unit cost and net income. Since there is no absolute index, however, it is impossible to do more than determine averages as a basis for comparison. In this way there will be farms producing yields higher or lower than average at costs higher or lower than average, and the net incomes will depend on this.

When comparing the production values of wheat varieties or variety groups the data of national variety trials must primarily be taken into consideration, complemented by farm experience. But the main objective is to find out how to exploit the potential productivity of the varieties under the given conditions.

BAUER, F.: An evaluation of the yields of wheat growing farms, i.e. a wheat growing "competition", can never take place under perfectly identical conditions, since the soil of the field, the distribution of precipitation, the degree of mechanization, etc. vary from farm to farm. It is a compromise if, on the analogy of short and long races, the farms are placed into different categories according to the size of the wheat area. Once a uniform system of soil classification has been introduced soil quality categories can be set up as well. The system of evaluation may be improved by adopting the concept of standard bread wheat, taking into consideration the lower price for fodder wheat and the higher price for quality wheat. Yield determinants which are subject to human influence, like variety, production technology, etc., cannot be used as the basis for classification. These are the very questions that the competition should encourage the farms to solve; these are what should be compared. Naturally, both the judge and the competitors must accept the fact that even a perfectly fair evaluation cannot be other than an approximation.

BEKE, F.: A basis of comparison between regions is provided by the indices obtained from the data series of wheat yield averages over the last 10 years published by the Central Statistical Office, and by their standard deviations.

National 10 years yield average = 100.

	Average	Fluctuation	Extreme values
		%	
1. West Transdanubia (Sopron, Vas, Zala counties)	95.8	6.4	92–105
2. Lowland parts of Győr, Fejér and Komárom counties	115.2	6.1	106–123
3. Transdanubian Central Range of Hills; Veszprém, Komárom and Fejér counties, Danube Bend	97.6	12.4	83–110
4. South Transdanubia; Somogy, Baranya and Tolna counties	105.8	9.9	91–116
5. Hilly region of the northern Great Plain; Nógrád county, Cserhát, Mátra, Bükk and Zemplén hills	85.9	17.8	55–101
6. Northern part of the Great Plain; Pest, Heves, Hajdú and Szabolcs counties	106.3	12.6	96–121
7. Tisza region, areas at the upper, middle and lower reaches of the river Tisza; areas between the rivers Berettyó and Körös, Körös and Maros	100.2	15.1	78–119
8. Area between the Danube and the Tisza; Pest and Bács counties	108.5	12.6	93–123

There are some very low values among the above data (Foothills of the Alps 92, Kemeneshát in West-Transdanubia 92, Hilly country in Zala county 89, Central part of Somogy county 91, Danube Bend 83, Bükk Hills 86, hilly area of Borsod county 55, Zemplén Hills 80).

Regions giving large yields are: the Bácska table-land (South-Hungary) 123, Mezőföld (South-West Transdanubia) 123, are between the Körös and Maros rivers 119, Győr basin 117, Tolna—Baranya lowland 116.

These data make it possible to compare regions with identical or nearly identical conditions. Sub-regions within the large production regions show similar fluctuations. The latter, however, are due to deficiencies in equipment, management, optimization and crop structure. Fluctuations of 50—130% occur not infrequently even within the same farm. The above data provide some basis for comparison, but further data series are necessary if general conclusions are to be drawn.

BOCZ, E.: Extremely thorough methodological preparation is necessary if wheat production is to be analysed. Factors influencing the yield have to be classified according to the aim of the analysis. Accordingly, the water and nutrient level of the soil will be the basis of comparison rather than the nutrient supply.

Farms and regions should be grouped on the basis of numerical parameters. The production factors are analysed within these groups, bot physiological factors (water and nutrient supply, soil cultivation, weed control, plant protection, crop rotation, harvesting, etc.) and those that can be expressed in monetary value and which provide the basis for economic calculations.

The better the numerical reflection of the actual situation which is given by the methods of yield analysis, the closer we get to the truth. This in turn will help in optimizing the production factors and evaluating the human activity and the extent to which it has contributed to the yields.

BODNÁR, M.: To the best of my knowledge there are no completely accurate and reliable methods for making an exact comprehensive comparison of the yields of farms growing wheat under different conditions. There are, however, numerous possibilities of carrying out comparative analyses with satisfactory accuracy, some of which have been mentioned in the answers to previous questions.

BÖRZSÖNYI, L.: In my opinion one expedient way of solving the complex of questions raised would be the following. A questionnaire as comprehensive as possible should be constructed to give a national survey of factors which influence wheat yields to a considerable extent, giving close attention to individual peculiarities and including all the dominant factors which seem impossible to compare.

The preliminary contents of a questionnaire concerning the 1976 wheat yields might be as follows (the numbers in brackets indicate the question to which they refer):

- the size and proportion of the growing area within the main branches of agriculture in a given farm (2);
- distribution by regional unit, i.e. the ratio of the examined are to the total wheat growing area (3);
- is the wheat area small, optimum or too large? (4);
- soil conditions, the location of the land, climatic conditions (5).
  Note: Categories should be formed within these characters and coded in accordance with the local conditions: e.g. soil type, pH, viscosity in L% (sedimentable part), mechanical composition (heavy, light) of the soil, etc.,
- is the area suitable or less suitable for wheat production? (6)
  Note: Here again it would be advisable to increase the number of categories, taking into consideration the 9 characteristic soil types in Hungary;
- fodder wheat or bread wheat? (7);
- quality of non-quality bread wheat? (8);
- unit cost of production (9).

Further factors suggested for inclusion are: manuring, artificial fertilization or both?

- soil cultivation level,
- wheat variety grown,
- further biological and agronomic factors,
- other specific factors.

The questionnaire should be constructed in such a way that it would be suitable for computer processing. This means primarily the correct choice and coding of the categories.

With a view to a correct biometrical and mathematical statistical evaluation it is essential to create a common ("identical") basis for evaluation. A proper connection between the factors can be established by means of a suitable system of weighting. On this basis and through a certain amount of selection it is possible to construct biometrical and computer models which make the problem easier to handle and allow partial and joint effects to be measured.

Of the possible methods of mathematical statistics, the multivariate (biometric) methods appear to be the most promising. A more exact specification and selection of the method or methods used to produce the solution is advisable in an advanced phase of the task. This also applies to other specifications as they become due and to individual comparisons between certain parts. On the other hand, hidden correlations which exert their effects through each other should be spotted and given increased attention right from the beginning. For example, the financial aspects mentioned in question 7 may represent a strong "background variable".

If a good evaluation and system plan is constructed, the proper simulation modelling and computer processing of the task in question, and the rational handling, storage and up-dating of the wheat yields in the year concerned as a national data base can be carried out simultaneously.

DEBRECZENI, I.: If the future development plans for wheat production in Hungary are to be put into practice, it seems to be reasonable to evaluate the yields of previous years all over the country. I should like to contribute to this evaluation with some details which are important from the point of view of plant production.

The data given below are taken from Vol. 3 of Agricultural Data in the Quarterly Statistical Publications for 1973, 1974 and 1975, in which the yield averages for wheat grown on soils with different quality (fertility) in 1972, 1973 and 1974, and certain economic indices which I consider important are found within the same system. In the subsequent publications this is no longer so.

In the period examined 4.0—4.8 million tons of wheat a year were produced in Hungary on 1.2—1.3 million ha of mainly chernozem, brown forest and meadow type soils. Wheat production took place in large-scale co-operative and state farms each several thousand ha in size and all practically fully mechanized, though with the exception of a few thousand ha all without irrigation.

It follows from the socialist land ownership and the national yield registration system that the evaluation is based on the yield data of co-operative and state farms, and the yields of the two types of farms are constantly being compared. This seems to be reasonable partly because the wheat yield averages are significantly different in the co-operative and state farms. For example, in the years examined the yield averages of the co-operative farms were 3.05, 3.43 and 3.71 tons/ha, and of the state farms 3.59, 3.90 and 4.18 tons/ha, respectively. Since the yields are higher in the state farms, it should be possible to increase the yields of the co-operative farms too. Theoretically, an analysis of the yield components in the state farms and the subsequent application of the most important of these factors in the co-operative farms would necessarily increase the yield in the latter.

What, then, are the factors that account for the higher wheat yields in state farms and the lower wheat yields in co-operative farms?

The soil conditions exercise a decisive influence on the average wheat yield in both the co-operative and state farms.

In Hungary differences in the quality of the soil are best expressed by the so-called gold crown value. The gold crown value was established in the 1880s. Since then it has been regarded and used by the authorities as the only basis on which to judge land quality, and for lack of anything better agriculturists also resort to this. The value of poor quality land is about 15 gold crowns per ha, while good lands are worth 30 gold crowns/ha. In the years examined the soils of Hungary were placed in nine groups on the basis of their gold crown values. The groups are subsequently marked with Roman numbers: I = 10.5 and under; II = 10.6—14.0; III = 14.1—17.5; IV = 17.6—21.0; V = 21.1—24.5; VI = 24.6—28.0; VII = 28.1—31.5; VIII = 31.6—35.0; IX = 35.1 gold crowns and over.

The data in the table show that the wheat yield is decisively influenced by the quality of the soil (Table 1). The surplus yield per ha on the best quality soils is 1.4 tons in the co-operative farms and 1 ton in the state farms compared to the poorest soils. This fact is a warning not to extend the wheat area so as to include soils of inferior quality. Yield reliability is ensured by soils of better quality.

The state farms produce considerably larger average yields than the co-operative farms on soils of the same quality. The difference is 0.4—0.7 ton/ha (the national average is 0.5 ton/ha) in favour of the state farms.

In the present situation the most important thing is to find an answer to the question of why the wheat yield averages are higher in the state farms than in the co-operative farms.

The annual wheat area is 1.1 million ha in the co-operative farms and about 180 thousand ha in the state farms. The difference in sowing area does not, however, give a satisfactory explanation, since both the co-operative and the state farms produce wheat on areas of several thousand hectares. The possible advantages or disadvantages involved in smaller (2—3 thousand ha) and larger (8—10 thousand ha) farms affect both state farms and cooperatives.

In connection with the sowing area, the question arises what proportion of the total production area is occupied by field crop production in the two types of farms. If the difference were large, the lower or higher proportion of some other branch of cultivation (e.g. pasture) might possibly be responsible for creating favourable or unfavourable conditions for wheat production. This is not the case, however, because the proportion of arable land is 70.8% in the co-operative farms and 68.8% in the state farms, in other words, nearly the same.

The proportions of the different field crops may also influence the wheat yield. In this respect the state farms have a definite advantage over the co-operative farms. The wheat area is 28.4% of the arable area in the state farms and 32.3% in the co-operative farms on average. But the important point is that the difference is generally made up by perennial papilionaceous roughage crops. Their average sowing area is 18% in the state farms and 13% in the co-operative farms. It is unnecessary to discuss

Table 1

Wheat yield average, sowing area of wheat, value of fixed assets, material and labour costs and fertilizer utilization in Hungarian co-operative and state farms on soils of various quality (fertility) averaged for 1972–1974

Soil quality	Wheat yield average, ton/ha	Sowing area of wheat, ha	Value of fixed assets, Ft/ha	Production material	costs labour	Fertilizer active agent kg/ha
				Ft/ha		
Co-operative farms						
I	2.72	93,967	13,187	6,077	2,597	200.4
II	3.01	164,257	17,599	8,905	3,431	218.1
III	3.25	213,771	19,774	9,525	3,466	245.0
IV	3.46	225,895	20,925	10,512	3,873	254.6
V	3.61	145,791	22,338	10,839	3,972	265.4
VI	3.76	129,017	22,819	11,566	4,067	268.2
VII	3.90	54,796	24,535	12,960	4,258	280.1
VIII	3.84	27,940	26,580	13,959	5,758	270.0
IX	4.09	37,567	25,744	14,782	5,468	282.4
Average	3.40	1,093,001*	19,639	9,762	3,640	247.1
State farms						
I	3.45	10,022	26,861	16,178	2,946	296.1
II	3.43	30,186	34,738	14,424	3,855	319.9
III	3.62	31,524	40,799	25,130	4,323	358.6
IV	3.94	34,139	38,758	19,410	4,470	360.6
V	4.03	26,532	40,052	21,399	4,558	357.1
VI	4.32	21,714	50,076	29,079	5,595	384.5
VII	4.30	17,397	48,497	31,546	5,835	377.8
VIII	4.54	7,580	64,753	36,163	7,150	341.5
IX	4.38	4,807	42,248	23,203	5,137	300.8
Average	3.89	184,901*	40,052	22,221	4,491	352.8

* Total

here the favourable effect of perennial papilionaceous plants on soil fertility, and consequently on the yield of other crops, in this case of wheat.

However, I feel that the higher yield average in the state farms can be basically explained by the fact that the farm work carried out in the state farms is of greater financial value than in the co-operative farms.

The average value of fixed assets per hectare is 40 thousand Ft in the state farms and not quite 20 thousand Ft in the co-operative farms. But this double amount of fixed assets applies not only on average, but for several thousand hectares of various quality soils too. Naturally, this serves as the background for production. More valuable fixed assets means more machines, equipment, buildings, vehicles, more efficient land consolidation, etc., which has a favourable effect on wheat production as well. With better soil cultivation, seed is sown at an optimum time, at a more uniform depth and with an even distribution; germination is more even, more plants overwinter, plant protection is more efficient, harvesting losses are reduced, and the crop is easier to handle. All this fundamentally contributes to an increase in yield.

The higher fixed asset value requires better organization and more work, so the production costs will necessarily be higher. Higher quality seed, larger volumes of fertilizer, pesticide, etc. are needed. It can thus be said that in general higher material and labour costs result in higher, more reliable yields and that this is characteristic of the state farms. The material and labour costs make up nearly 27 thousand Ft/ha in the state farms and only half as much in the co-operatives on average. The double cost of material and labour in the state farms is, however, characteristic of the different soil groups too. The cost of wheat production is obviously lower than this, but proportionately it is likely to follow the same trend, i.e. in the state farms the material and labour costs for wheat production are higher than in the co-operative farms.

One of the major factors in attaining large yields in crop production is the amount of fertilizer utilized. A reasonable increase in the rate of fertilization results in larger yields. The cost of fertilizer utilization is included in the production costs, but from the point of view of cultivation it is more than this, since the effect of the fertilizer used in any one year may last for several years. This is particularly so for phosphate fertilizers. Furthermore, larger doses of fertilizers increase not only the yield but also the root mass of a given crop, which is subsequently a valuable means of increasing the fertility of the soil.

The fertilizer active agent used for one hectare of arable land is greater (an average of 352.8 kg) in the state farms than in the co-operative farms (247.1 kg). As regards fertilizer utilization in the different soil quality groups, the table reveals that the co-operative farms use less fertilizer for the poor soils and more for the better ones. The utilization of fertilizers is more uniform in the state farms, although they also use less for the poorest and best soils.

Since wheat is sown over a considerable area it also receives much of the fertilizer distributed on the arable area. In fact, the general nutrient supply available on the several thousand hectare area of each soil quality group appears to be sufficient for wheat, which is mostly grown in rotation. One of the main reasons for the higher yield average of wheat in the state farms is thus the larger fertilizer consumption.

The role of soil quality in the wheat yield averages in the state farms is also obvious when they are evaluated in soil quality groups. While the amount of fertilizer applied in the different soil quality groups is nearly identical, the per ha yield nevertheless increases with the quality.

All in all, an analysis of the national wheat yield data reveals that wheat is grown more efficiently in the state farms than in the co-operatives. The better yields are explained by the smaller proportion of wheat among the field crops, which has made it possible to increase the sowing area of perennial papilionaceous crops; by the higher rate of fertilization per unit area; and by the higher value of the fixed assets and the higher unit material and labour costs, which enable the up-to-date production technology to be fully applied.

ECSEDI, J.: To start with, it should be made quite clear that there are a great many possible methods of evaluating a phenomenon or thing. First of all, the purpose of the evaluation must be clarified, since this greatly influences the scope and method of the investigation; in other words, we must decide what, why and how to analyse. In the present case if these questions are answered it may become apparent how yields can be compared.

Following this, an assessment of the data requirements can be made and the experimental material can be chosen, studied and checked for correctness. I consider it very important to take stock of the ecological, technical, economic and organizational factors that influence the wheat yield trends. These factors are highly diversified. Some can be changed at will (nutrient supply), while for others the possibilities of interference are very restricted (some of the ecological factors). This circumstance is of great importance from the point of view of the analysis.

The factors that influence the yield exert their effects in a complex way. The different groups of factors and their individual elements are present to a different extent and in varying proportions and quality at each growing site, and also differ in time and with the phenological phases, so they produce a great diversity of action mechanisms. This is why the application of an accurate method of evaluation is so difficult; not to mention the fact that if a mass analysis is to be carried out to cover a large area, the very size of the data pool sets a limit to the depth of the analysis.

So what can be done to ease the problems? Bi- and multifactorial experiments and various types of analyses show that the weight and role of the yield-forming factors differ considerably. If this is taken into consideration together with the character of the factors as outlined above, a group of factors can be selected in which the members show a relative constancy and play an unambiguous and clear role in forming the yield.

Such a group of factors is formed, in my opinion, by the ecological factors, including the site conditions, and particularly the quality of the land, and the type and fertility of the soil. Admittedly, the methods of sizing up and expressing these qualities (e.g. by means of the gold crown value) are not perfect in every respect, but in carrying out an analysis at any given time a compromise must be made. The line must always be drawn somewhere.

If on the basis of the above criteria homogeneous regions and districts are marked out, analyses for any purpose will become considerably easier. In order to promote the rational regional location of crop production or to evaluate the farm management the setting up of such districts has been attempted at various institutes (G. Géczi, Production Development Institutes of the Debrecen and Keszthely Universities of Agricultural Sciences; Statistical Centre of the Ministry of Agriculture and Food; Research Institute for Soil Science and Agrochemistry).

We ourselves, for example have placed the farms of Hajdú-Bihar county into 3 regional units, primarily in order to make a comprehensive evaluation of the standard of farm management. This is largely in agreement with the districts set up by the statistical Centre of the Ministry of Agriculture and Food and the Research Institute for Soil Science and Agrochemistry.

Since a regional unit includes farms with similar site conditions it becomes possible to select yield-forming factors which are relatively easy to handle. The yields and economic success of these farms can then be safely compared. A comparison of this type not only determines the order of merit, but also answers the question of how the available natural resources have been exploited by the farms in general, and by the individual branches of agriculture in particular.

If there is an adequate data pool this method of analysis will disclose a wide range of causal relations. Thus, for example, by placing farms producing the highest and lowest average wheat yields in the region in separate groups the extreme values of the region characteristic of the given period are obtained. To this the measured or demonstrable data of the yield-forming factors are added, naturally in such a way that each group is represented by its own weighted averages. The comparison of the two data series and the differences between them demonstrate, at least in tendency, the cause of yield differentiation. The more, reliable data which is available to represent the yield-forming factors and the differences in order of magnitude and proportion which exist between the two extreme groups in the region concerned, the more valuable the analysis will be.

Naturally, many other methods could be used to evaluate wheat yields. For example, the production systems generally use two-way or occasionally multivariable functions and regression analyses. These calculations, together with the experimental results, may characterize the nature and closeness of the correlation between the factors (variables), and offer a sound basis for the development of the technology and the establishment of correct proportions between the production factors.

Among the possible methods it is worth mentioning factor analysis, with which a large number of factors can be simultaneously evaluated. This is suitable for determining the role of the individual factors or factor groups in the yield tendency, and can also be used to put the farms in order objectively. It has the advantage that the area limits of the investigations can be extended, since the method incorporates the site conditions into its system of factors.

However, this method too can be better used within regional units formed according to the site conditions. Since, in this case, the values of the factors characterizing the site conditions are more unified, the method gives a sharper demonstration of those yield-forming factors which are easier to modify.

FRENYÓ, V.: Any objective comparison of the yields of wheat-growing farms is only possible in a complex way, i.e. with the joint consideration of many interrelated indices, and even then only after appropriate grouping. The aspects considered when grouping might be: natural conditions (soil, climatic, site and other conditions); whether or not large-scale fields have been properly created; whether wheat growing is generally dominant in the crop production of the farm; to what variety group the wheat grown in the farm belongs.

Within groups of the same type production efficiency can then be compared on the basis of the following parameters: yield per unit area; total production cost per unit weight; quality of the wheat crop.

A system of scoring, which was previously used mainly for a thorough individual evaluation of animals, would be a suitable complex biometric and economic method of comparison. With this method each character is separately evaluated. The indices thus obtained are weighted according to their importance, then totalled. An analytical model developed in this way is also suitable for computer processing.

HUSTI, M.: Statistical data on agricultural yields in Hungary have recently been published with reference to four large geographical regions. These are:

— Transdanubia,
— Danube—Tisza Mid-Region,
— Trans-Tisza,
— Northern Hills.

In this way yields could be compared within the regions, taking certain differences in the farming conditions into consideration. These differences mainly reflected the meteorological conditions.

On the other hand, it must be accepted that certain basic factors of crop production cannot be separated from one another, because they jointly influence the yields.

In a simplified form the factors that influence crop production can be placed in three groups:

— *socio-economic factors:* structure of the labour force, market conditions, etc.;
— *technical and material factors:* technological level, fertilizer and pesticide supply, etc.;
— *ecological factors:* soil, water, genetic properties of the varieties, etc.

In the large geographical regions great differences in these factors can be pointed out, so a yield comparison would not be realistic.

When examining Transdanubia as a geographical region a series of ecological districts can be distinguished:

1. Flat land along the Danube
2. Mezőföld
3. Flat land along the Drava
4. Győr basin
5. Marcal basin
6. Komárom—Esztergom plain
7. Foot of the Alps
8. Sopron—Vas plain
9. Kemeneshát
10. Zala hill-country
11. Outer Somogy
12. Inner Somogy
13. Tolna—Baranya hill-country
14. Mecsek and Mórágy block
15. Bakony hills
16. Vértes and Velence hills
17. Danube-corner hills
18. Danube-bend hills

In these smaller districts the most important factors are almost identical.

It is realistic to compare the yields within an ecological district.

So how should the yields of wheat-growing farms be evaluated and compared?

First: by setting up size categories:
below 300 ha,
300—600 ha,
600—900 ha, and
above 900 ha.

Second: by comparing the ecological districts for
yield,
cost, and
efficiency.

Third: the ecological districts of the geographical region can also be compared with such a method.

The comparison would also point out a number of close correlations. In simple terms: the yields can thus be "screened".

I am convinced that in the course of "screening" it is possible to decide whether it is worthwhile growing wheat on a given area or whether it would be better to utilize the land for other crops. To the best of my knowledge no selection of this type has been made so far, although at the present level of farming it will soon be inevitable. Specialization will also be necessary in the future.

A study of how our natural conditions are "managed" would probably reveal considerable waste. This fact must not be ignored.

An adaptation to future requirements would certainly improve the present situation and would encourage the farms to attain the maximum possible yields.

In my opinion, the determination of an economical volume of plant production, and its realization in practice is the only correct path to be followed in the future. As far as I know a scientific survey to this end is now in progress.

KÁDÁR, B.: A relatively objective comparison can be made if economic conditions which are independent of the farmer's intentions and cannot be influenced within the given period are eliminated. In the case of wheat production this means that the comparison will give correct results when it is carried out within groups set up according to growing sites, soil types, irrigated or non-irrigated conditions, etc.

KISS, Á.: When evaluating the yields of wheat-growing farms the farming conditions must be taken into consideration. A comparison can only really be made between those possessing identical conditions and supplying similar products. I should definitely make a distinction between areas with good and poor conditions. Since farms on areas less suitable for wheat growing produce lower yields at higher costs, wheat production on such farms should be aided by government credits, which should be interest-free or at a very low interest. The amelioration of poor growing sites is very expensive. This has to be accepted, but at the same time there are many areas unsuitable for wheat growing which can nevertheless be improved to such an extent that a medium yield could perhaps be expected, depending on the weather; and this fact must not be ignored. In short, wheat yields produced on areas with poor conditions cannot in my opinion be compared to those obtained under good conditions. Yet, it is in the national interest to grow wheat wherever wheat production is possible at all, even if the yield is half of that obtained in farms with favourable conditions; and if necessary the government should give assistance in the manner suggested above.

LÁNG, B.: Hungary is situated in the wheat growing zone. However, the soil and climatic conditions of the country produce varied yield averages. Nevertheless wheat yields must be evaluated and this can be carried out by comparing those obtained under similar conditions.

As a results of compulsory, uniform soil analyses suitable indices are already available. Some of these are constant or only change slowly, such as humus percentage, viscosity number and water capacity. Data on meteorological factors such as precipitation, temperature, number of frosty days, etc. are also known. These factors should be utilized to set up production regions. If the farms are examined according to the regions thus formed, well managed farms will be encountered in each and these will determine the yield levels that can and must be achieved in the respective regions.

I do not wish to go into the problems related with the ever decreasing arable area and the ever increasing demand for wheat.

LELLEY, J.: A comparative evaluation of the yields of wheat-growing farms is no easy task. The questions already discussed make it clear how many factors of uncertainty play a role in this. In my opinion when comparing farms for yield the economic data are the most important, in other words, at what cost the farm produces 1 ton of what and how its investments compare to those of other farms. However, a simple profitability calculation is only really characteristic if it represents long-term economic efficiency rather than a short-term profit. In other words, if it looks to the future rather than counting on the marketing possibilities of a momentary boom, but at the same time does not leave a single possibility unexploited and utilizes its own abilities to the maximum. All this, however, requires sound professional knowledge, experience and a simple accounting system. The necessary professional and administrative staff should already be available in both state and co-operative farms, but the general opinion is that this capacity is not fully exploited at present.

NÉMETH, S.: It is practically impossible to establish an absolute, exact basis of comparison for the evaluation of wheat yields. The effects of the biological, ecological, technological, managerial, etc. factors forming the yield are felt in a complex manner. However, the use of computers now provides a possibility for studying the correlations between yield factors. These factors are well known: variety, nutrient, precipitation, temperature, forecrop, soil, etc.; a thorough consideration of these conditions when constructing the computer programme ensures the objectivity of the evaluation at a relatively high level of significance.

NYÉKI, J.: Wheat is only one of the major crops in Hungarian farms. Although yield trends are important when evaluating farm efficiency, this is not the only basis on which to decide the degree of economic efficiency. Nevertheless, it would be important to find out how the yields of different farms could be compared.

Considering that the use of materials not produced by the farm itself plays an ever increasing role in determining the yield, and the production of these materials is a great burden on the national economy, it seems reasonable to compare the wheat yields on this basis.

With a view to forming a correct judgement I suggest that consideration should be given to how much nitrogen, phosphorus and potassium fertilizers, pesticides and fuel the farm uses to produce 1 ton of wheat.

The calculations would be still more exact if the amortization rate of the machinery used for wheat production were added to these data.

In fact the amortization value could be calculated with the fuel, since the amount of fuel consumed is more or less proportionate to the amount of mechanical work required for cultivation.

So far, no mention has been made of quality, which may become more and more important in the evaluation. A modifying factor should be calculated for the above data which would depend on the difference in value between quality and fodder wheats.

I have deliberately not taken differences in soil and site conditions into consideration, because after processing the above data it will become evident in which region and on which farms wheat production is worth encouraging and developing.

PÁSZTOR, K.: In evaluating the yields of wheat-growing farms the site conditions (good, medium and poor wheat areas), the technology applied and the variety used (fodder wheats or varieties suitable for human consumption) should be taken into consideration in order to create a sound basis for comparison. The unit cost must also be examined, as the cost at which the farm has attained the given yield is not a matter of indifference.

If the evaluation is to be more exact factors influenced by human activity must definitely be separated from those which are beyond human control (soil quality, climate, weather). Any product which is highly dependent on human activity can be compared irrespective of the size of the farm provided the area reaches a minimum size (e.g. on which soil preparation, sowing, fertilizer distribution and other operations can be mechanized). If, on the other hand, factors beyond human control play a decisive role in forming the yield the comparison is not realistic.

PETRASOVITS, I.: The Water Management and Amelioration Department of the Gödöllő University of Agricultural Sciences has been dealing with the methodology of defining numerically the action ratio of factors forming the yield for a number of years.

The main yield factors are placed in 4 groups:

1. the capacity of the natural conditions, i.e. the system of primary resources (atmosphere, ground surface and hydrological cycle);
2. the requirements and production potential of the variety, i.e. the biological material;
3. production technology aimed at maintaining a relative amount of harmony between factors 1 and 2; and
4. amelioration, if the capacity of factor 1 is not sufficient to fulfil the requirements of the variety or the technology.

The participation of these groups of factors in the yield can be numerically defined, with some variations from year to year.

PLETSER, J.: The present method of evaluating the wheat yields of farms does not make it possible to discover the reasons for the differences. Naturally such values as the national average are necessary, as they enable us to determine where we stand in the world. Besides this general information, however, the lowest and highest yields should also be published. The next stage is the county yield average, which is usually broken down further to state and co-operative farms. No information beyond this is available to the public. These data do not reveal the causes of yield differences.

Today, when computers are available for data processing, a yield evaluation that includes the reasons for significant yield differences presents no problem. Soil and climatic conditions are obviously among the causes, though these can be counterbalanced by shooting the right cultural practices and variety. It has long been known that the yield is much higher in experimental plots than in the farms. A better approximation of the biological potential cannot be achieved until the causes have been discovered.

Yield evaluations without meteorological data cannot be objective. Obviously the soil, variety, cultural practices and farm management cannot be ignored either. But since I am a meteorologist I should like to concentrate on the effects of the weather. I have read many publications in which the climatic requirements of a variety are established on the basis of a three-year study without a climatic evaluation of the weather conditions in the period of the study. And in practice, farmers do not even consider three years in most cases. Variety, cultural practices, soil conservancy are planned on the basis of the previous year's experience, which usually involves an unacceptably high risk. If the crop is successful after all, the farm takes the credit, while "objective difficulties" are blamed for a failure. And this situation will remain until the method of yield evaluation is changed. I do not mean to imply that the damage caused by the weather can be completely eliminated by improving the evaluation method, but if the causes are known the risk can be lessened and the possible production losses reduced. As an example I could mention wheats with poor frost-hardiness. In the slightly colder than average January of 1979 many wheats suffered frost damage. The sowing area of these frost-susceptible wheats was not reduced in proportion to the damage experienced in 1979—80. Winters much colder than this may occur in Hungary, as shown by the temperature series for the last two hundred years (Magyar Mezőgazdaság 1980, No. 3).

SVÁB, J.: I can answer all the questions concerning the evaluation of wheat yields in the affirmative, since I definitely consider the yields of different farms, fields, growing sites, wheat types and varieties to be comparable. What conclusions can be drawn from the comparison is a different matter. It must therefore be decided in advance what the aim and method of comparison are to be.

The usual methods of grouping and averaging generally only offer the possibility of a very narrow comparison of little practical value, because the production process takes place in a multivariate environment. Therefore, in the overwhelming majority of the questions, evaluation can only be carried out by using multivariate statistical methods, or less often by the analysis of frequency distributions. These methods can be applied using computers.

As I have been engaged for years in analysing the farm data of a number of crops, I should like to point out that this problem is far from simple and has still not been satisfactorily solved. In most cases the joint effect of many variables must be taken into consideration simultaneously in order to obtain a correct answer concerning the effect of even a single production factor, because otherwise the effects appear in a highly confounded manner and the conclusions may therefore be incorrect. It is to this multivariate situation that data surveying, i.e. questionnaires, the evaluation methods and the professional interpretation of the results should be adjusted.

SZABÓ, B.: Wheat continues to be an important food crop. Under the present price conditions it can be efficiently and profitably grown in most farms. Apart from regions with extreme soil and climatic conditions low investments give relatively good yields.

Since the crop structure is increasingly decided by the farms themselves, it is mainly determined by economic considerations, as is the sowing area of wheat. In my opinion, it is unnecessary to search for ways and means to make exact comparisons between the wheat yields of different farms, since farms which are unable to produce satisfactory yields can change their profile.

In fact, the present method of evaluation on the basis of the yield is quite acceptable; at most the gold crown value could be taken into consideration when putting the farms in order of merit.

SZALAI, GY.: In my opinion the yield average of bread wheat in Szolnok and Hajdú-Bihar counties should be taken as 100%. (The gold crown value for the arable land of the two counties is 20.5.) To this, three corrective factors should be applied, namely:

1. gold crown value
2. climatic conditions
3. wheat quality

With a view to this the influence of each of these factors on the wheat yield should be quantified. The problems discussed in questions 1 to 4 deviate from the average and should be considered separately.

SZEDERKÉNYI, E.: If different prices are paid for wheat according to the quality a balance is promoted between the interests of the national economy, the processing industry and the farmers. A purchase price based on weight and quality, and the use of reliable instruments for measuring these promise advantages in all phases of production. The greatest advantage of a wheat purchase system based on quality is that it leads to the production of better quality wheat which is more suitable to the purpose of utilization. Payment for quality should not exercise any unfavourable effect on the economic efficiency of wheat production as a whole, while it should encourage the improvement of quality.

At the initiative of the Ministry of Agriculture and Food very important experiments were carried out in 1978 concerning payment for quality. Twenty-five purchasing stations of the Cereal Trust and 300 large-scale farms delivering their crops took part in the experiment. The experience gained, together with subsequent experiments in 1979 have made it possible to improve the methods of quality testing and modify the purchasing system.

The preconditions for an objective system of buying up wheat according to quality are:

— only one variety in each lot,
— reliable sampling,
— classification by qualities important for the final product,
— reliable quality testing instruments and rapid methods,
— appropriate laboratory network and competent professional staff,
— storage capacity enabling storage according to major quality groups,
— a purchase price giving a bonus for qualitative characters in accordance with their importance for the food industry.

A characteristic feature of the process of buying up wheat is that 70—80% of the marketed crop is bought up within 20—25 days, simultaneously with the harvest, and that quality testing was previously based mainly on physical properties. However, to satisfy the quality requirements not only the physical and organoleptic characteristics but also the variety, wet gluten content, gluten elasticity, organoleptic gluten quality, valorigraphic value and enzyme activity of the individual lots of wheat must also be known. The majority of quality tests are time-consuming, so they cannot be completed simultaneously with the unloading of the trucks arriving at the station. Thus, the different wheat varieties delivered continuously during the harvesting period cannot be stored separately in accordance with the results of the quality tests. On the other hand, the individual lots can be separated according to variety (as guaranted by the farm) or on the basis of organoleptic and physical tests. Provided sufficient storage capacity is available the quality of the wheat will be much more differentiated than it was previously. And after the completion of the quality tests the farm will be given a price corresponding to the quality of the wheat delivered, which may encourage an improvement in quality. According to the new regulations a separate marketing contract has to be made for high quality wheat and this wheat must be separately stored until it is delivered.

Studies on quality have revealed that a certain quality interval is characteristic of each variety, though there is obviously a certain amount of overlapping and variation. The varieties GK Tiszatáj and Partizanka give the best quality. The Martonvásár (Mv) varieties, and also Bezostaya 1 and Jubileinaya 50, have less constant quality but excellent milling value. The GK and NS.Rana varieties are of poorer quality, although in 1978 NS. Rana 3 was found to be of good or medium quality as well as having excellent productivity. Thus, if wheat is bought up according to the tested quality, the purchase price will be differentiated by the quality irrespective of the wheat variety. Nevertheless, the probability that a certain level of quality will be attained is associated with the variety. Therefore, in establishing price ratios the yield potential and cost-profit ratio of varieties giving different quality must be taken into consideration.

In examining the price ratios quality factors which are due to the correctness or deficiency of the production technology (water content, overdryness, impurity, proportion of broken grains, healthiness, etc.) rather than to the genetic traits of the variety can be ignored, although they influence the delivery price even in the present system. According to the new regulations:

— Wheat varieties classify as bread wheat if they are proposed to the Ministry of Agriculture and Food as such by the National Council for Variety Testing, if they meet the requirements of standard MSZ 6383 on "Wheat for eating purposes", if the baking quality (tested with a valorigraph or farinograph) is at least B_2 and if the hl weight is over 74 kg. The proportion of bug-eaten grains must not be more than 10%, nor must that of germinating grains.

— Bread wheat is classified as high quality wheat when its wet gluten content is at least 35%, the gluten elasticity is 2—5 mm, the baking quality at least A_2 and the proportion of bug-eaten grains at most 3%.

— Any wheat not qualified as bread wheat, and those, irrespective of variety, whose quality does not reach baking value B_2 or fail to meet any one of the minimum quality requirements, or contain more than 10% barley grains, are qualified as fodder wheats. Any wheat dried at too high a temperature (above 80 °C) is also classified as fodder wheat.

The prices paid to the farms for wheats of different quality are:

High quality bread wheat	3250 Ft/ton
Standard bread wheat	3100 ,,
Fodder wheat	2800 ,,

There is no decisive difference in production cost between the varieties, so the calculated sales returns for the different varieties give a fair indication of where the interest of the farmers lies. The 1977 yield averages of certain varieties, which were chosen somewhat arbitrarily, though the choice was justified by the 1978 quality tests, and their sales returns in large-scale farms are shown in Table 9.

The varieties have been placed in different price categories on the basis of the major findings in the quality tests, but this does not mean that particular loads of wheat cannot occasionally be placed in a higher or lower category.

Our calculations show that the new differential farm prices have lessened the farmers' interest in fodder wheat production, which is in the interests of the national

Table 9

Calculated returns from sales for some wheat varieties

	Yield average ton/ha	Price according to quality Ft/ton	Returns from sales Ft/ha
High quality wheat		3,250	
GK Tiszatáj	4.67		15,177
Partizanka	5.18		16,835
Mv 5	4.80		15,600
Standard quality wheat		3,100	
Jubileinaya 50	4.27		13,237
Mv 4	4.90		15,190
Fodder wheat		2,800	
Sava	4.83		13,524
Libellula	4.48		12,544
Zlatna Dolina	4.95		13,860

economy, and also encourage an improvement in quality. Whether the price difference between high quality and standard bread wheats will be sufficient to stimulate the production of high quality wheats is another matter. In 1977 the high quality wheats included in our calculations were grown on 1.6% of the wheat area and standard bread wheats on 40%. It can be supposed that if high quality wheat varieties were more widely distributed the national yield average would be lower, as seems to be proved by the results of the national variety trials, where varieties which generally give a standard quality are 8—10% more productive. In this case the 4.8% higher price of high quality wheat compared to standard wheat is no longer attractive to the farms. This is particularly so if it is considered that a special contract must be made for high quality wheats and that temporary storage has to be arranged. In my opinion, under such conditions the production of high quality wheats could be sufficiently encouraged with a farm price of about 3400—3500 Ft/ton.

I think the research results and methods prove the necessity of comparing the yields of bread and fodder wheats, and of quality and non-quality wheats. The information thus obtained is useful at a national and farm level alike. It may provide a basis for decisions, and may give farm policy the right orientation, corresponding to the interests of the national economy.

Szieberth, D.: I think the only way to obtain a correct evaluation of wheat production is to compare the actual to the potential achievement. At the present standard of winter wheat production in Hungary all the factors that have a decisive influence on the yield can be closely observed, the effects can be calculated and it may even be possible to control them. Taking this into consideration and assuming that the farm is well managed, an adequate prognosis of the prospective yield can be given, and the difference between the harvested and the possible yield can be determined to a close approximation.

Thus, I suggest that the yield attainable in a given field under the weather conditions of the given year should be chosen as the basis of evaluation. The index of the efficiency of the farm could be established through a synthesis of these. So, in addition to a thorough, detailed professional opinion, the means of evaluation would simply be a ratio, the maximum value of which would be 1. The standard of wheat production in a farm would thus be judged by its closeness to the maximum value.

Given the present economic situation in Hungary we cannot afford the luxury of not attaining the highest possible profit on every hectare of the total agricultural area. Farm size and crop structure must improve the standard of production rather than restraining it. Agricultural product is produced by the farm, but it is actually created by the production unit, in the present case by the field. The farm is made up of a synthesis of production units.

Essential measures required for the introduction of this system of evaluation are:

- The book-keeping system of the farms should be changed from a simple statistical system of registering and checking data to a process suitable for agro-economic analyses.
- The planned new type of field register should be introduced.
- The information system and computer network required for an analysis based on a large data pool should be constructed.
- Research institutes working in the field of crop production should be made directly interested in helping the farms to approach the maximum value of 1.
- Research on agricultural economics should aim at demonstrating why it is worth approaching the value of 1.

This system of evaluation would facilitate an objective comparison between farms, fields or other particular production units with respect to wheat yields, and would unambiguously show where unexploited possibilities lie and why they have remained in the much talked-of store of "reserves", rather than being put into practice.

Szilágyi, Gy.: The calculation and comparison of wheat yield averages has always been necessary and will be so in the future too. It cannot be denied that there have always been problems in this field. It would be desirable if the yield average always reflected the soil conditions and climatic elements of the area or region concerned, and the management level and wheat production possibilities of the respective farms. Unfortunately, such indices are not available, and even if they existed it would be very difficult to use them.

I think the most important thing is to record the yield grown, harvested and sold on the total wheat area of the country in a given crop year, irrespective of how the individual farms exploited their potential. This task has so far been carried out without any special difficulty, and the data have been more or less accurate.

From the point of view of the national economy any other consideration, such as pointing out differences between the farms, has a subordinate, though at present indispensable role, as will be discussed below.

Second in order of importance is the regular yield analysis carried out by the state research institutions in order to decide what varieties the farms should produce to attain a steady increase in the national yield average. This work will be indispensable in Hungary for a long time to come.

As regards differences in yield average between farms, production regions and particularly between counties, it is here that the most factors of uncertainty and the most errors are found. The farm can and must assess how successful wheat production was in a given crop year. These data can be used to evaluate the progress made in a given branch of agriculture. However, the uncertainty factors are considerable even within a farm, since wheat is not always grown in the same field, and the weather conditions also vary from year to year. The yield averages of two fields some distance from one another definitely cannot be judged in the same way. The forecrop, the nutrient level of the soil, its water content, the standard of soil preparation, damage due to pests and diseases, the extent of weed growth, the situation of the field, the cultivation methods applied, etc. are far from identical at different sites, and this greatly increases the possibility of drawing false conclusions from a comparison even if the same variety is grown. The yield on a given area is shaped by the interactions of innumerable (climatic, agrotechnical, soil, etc.) factors even within the same farm. The possible combinations of these factors are so numerous and varied that even in a small country like Hungary no two production areas or fields have completely identical conditions so that a reliable comparison could be made between them.

Nevertheless, for economic reasons it is necessary to know and compare the per ha yield data of areas at various distances from one another. I think the main purpose should be to establish the production costs in order to decide whether it is worth growing wheat on the area concerned, and if so, at what cost. The expected yields are considerably influenced by the professional ability of those responsible for wheat production, and by their knowledge of the local conditions, but even these experts cannot eliminate the role of other objective factors. In certain cases, for example, an average wheat yield of 25—30 q/ha produced by a farm in Veszprém county is a better performance than, say, a 50—60 q/ha yield attained "at half steam" on a farm in Békés county.

From a scientific point of view there is no point in comparing the yield averages of farms with different conditions. If this is nevertheless done, false conclusions may be drawn. For example, in 1979 a farm where varieties of exclusively Mediterranean type were grown was placed first on a national scale. I do not think any comment is needed as to what would happen if every farm followed this example and from now on grew exclusively Mediterranean wheats.

Finally, I should like to return to the main problem, namely that the total volume of wheat produced in the country could be further increased in the future, if all the farms stuck to the production technology and made use of suggestions based on the results of trials carried out by the National Institute for Agricultural Variety Testing, irrespective of whether an exact yield comparison between farms at various distances from each other can be made.

TARCSAY, I.: For some years now I have had the opportunity to attend conferences and action committee meetings on farm matters and hear the immediate responses of the interested parties to evaluation. This suggested to me that besides all other considerations the result attained so far by a given farm should be the norm to which the work of the collective could be compared. In other words, each farm should be evaluated by its own progress. This would prove the greatest incentive.

I have evaluated the average wheat yields between 1972 and 1979 for all the state and co-operative farms in the county. This has showed that:

in 35 farms the wheat yield average is definitely increasing because the professional standard is high, the agrotechnical discipline is improving, there is sufficient machinery available, and wheat is mostly grown on chernozem soil, which is also expressed in the gold crown value. The combination of science and practice makes its effect felt;

in 19 farms the average yield fluctuates. These farms are characterized by a diversity of topographic forms or by flat lands which need amelioration. The professional and agrotechnical standard is only medium.

In 14 farms no progress in wheat growing can be observed. In such places state intervention is indispensable. In these farms the subsidization of complex water management, an improved supply of machinery and the employment of more qualified staff is necessary. In some cases structural changes will also be required.

It has been found that when the possibilities of development are discussed on the basis of self-criticism by the farms, there is less resistance from the agricultural workers.

VÉSEI, Á.: The wheat yields of farms must certainly be evaluated. The question is, what the purpose and grounds of the comparison are.

Analysis and comparison should only be made on economic considerations. But the degree of economic efficiency depends on two important groups of factors:

a) those acting irrespective of human intervention: soil, climatic, topographic and hydrographic factors;

b) those determined by man:
- variety,
- technico-scientific equipment and the professional staff using them.

When comparing farms for wheat yield the soil conditions must primarily be taken into consideration. Good quality soil lessens the adverse effects of extreme weather conditions. The nutrient supplying capacity of the soil depends decisively on the soil type and can only be improved by long years of work and substantial investments (amelioration).

The best yields are obtained from medium size fields (100–150 ha). The way in which the fields are created depends on the topographic conditions and the situation of the area, which are factors beyond human control. This too must be considered in the evaluation. Growing wheat on an area of over 1,000 ha involves more work than for a smaller acreage, and this must be appreciated. The percentage wheat in the total arable area need not be taken into consideration; nor need the variety and the technical and technological level, because these are factors which depend on the farm management.

Thus, the factors to be considered in comparing the wheat yields of farms for the purpose of evaluation are: soil conditions, size of field, total wheat production area. However, the order thus obtained is still not complete. The efficiency of wheat production must definitely be pointed out to decide how wheat production should be developed in a given farm.

ZSIRAI, J.: In evaluating wheat-growing farms I should give them points from 1 to 10 on the basis of production area, soil conditions (expressed as gold crown value), amount of precipitation during the growth season, average yield over the previous five years and average unit cost over the previous five years, and then place them in 5 categories according to the points they have attained. Farms placed in the same category would be judged on the basis of the current year's yield average, according to the table below.

Size of area	0–200 ha 2 points	200–500 ha 4 points	500–1000 ha 6 points	1000–2000 ha 8 points	above 2000 ha 10 points
Soil conditions	10–15 gold crowns 2 points	15–20 gold crowns 4 points	20–25 gold crowns 6 points	25–30 gold crowns 8 points	above 30 gold crowns 10 points
Average unit cost in the previous five years	above 350 Ft 2 points	300–350 Ft 4 points	250–300 Ft 6 points	200–250 Ft 8 points	100–200 Ft 10 points
Average yield in the previous five years	0–30 q 2 points	30–40 q 4 points	40–45 q 6 points	45–50 q 8 points	above 50 q 10 points
Precipitation during vegetation period	up to 100 mm 2 points	100–150 mm 4 points	150–200 mm 6 points	200–250 mm 8 points	above 250 mm 10 points

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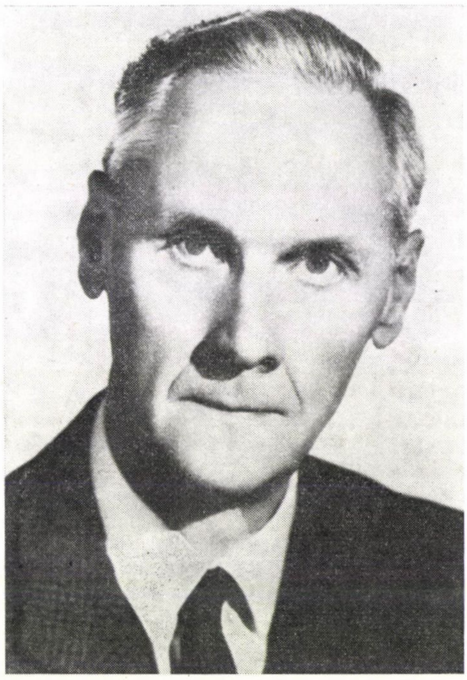
FORUM

OUR GUEST IS



PROF. ARTHUR HORN

HEAD OF THE DEPARTMENT OF ANIMAL HUSBANDRY,
UNIVERSITY OF VETERINARY SCIENCES

PÁL, GY.: *Professor Horn!*

In 1960/61 the grain import requirements of the developing countries were less than 20 million tons, in 1977/78 the grain imports rose to 70 million tons, and assuming the present rate of development they will need to import some 140—150 million tons of grain in 1990/91. This means that in the coming decades an ever decreasing volume of grain crops can be used to feed animals. Do you think that in the near future animal species which consume large proportions of rough and succulent fodder instead of grain will be preferred in livestock production ?

HORN, A.: It is quite certain that all over the world, and particularly in the developing countries, plant food will continue to play a decisive role, and less grain feed (concentrates) will be utilized in animal production. In countries with developed industries and agricultures, on the other hand, animal products will, in my opinion, continue to be much sought after in the future. The consumption of meat and dairy products in particular seems to have become fairly stable, apart from some fluctuations for economic reasons, and the range of goods has widened. This, of course, is only possible with the utilization of a considerable volume of grain feed. I am of the opinion that the agricultural production of the world can no longer afford not to exploit forage crops rich in fibre, such as the vegetation of pastures, the grass crops of the steppes and agricultural by-products (e.g. maize stalks, industrial by-products), to an increasing extent to feed ruminants.

Accordingly, the role of ruminants will undoubtedly grow all over the world; moreover, new herbivorous animal species, e.g. certain wild animals (hartebeest, etc.) which are better adapted to various ecological conditions than the usual domesticated animals, are likely to be included in agricultural production, especially in meat production.

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PÁL, GY.: *The climate of Hungary, with an annual precipitation of 600—700 mm, 2000 hours of sunshine and suitable daylength, is favourable to the development of the generative organs of cereals, i.e. for the production of grain feed, while the climate of Western Europe is more suitable for the development of the vegetative organs, i.e. for the production of rough fodder. So do you think it would be advisable for Hungary to concentrate on breeding animals which require grain feed (dairy cattle, pigs and poultry) and for Western Europe to concentrate on beef cattle production?*

HORN, A.: The climate and geographical conditions of Hungary are undoubtedly favourable for cereal production. However, the Hungarian climate also results in favourable yields of silage maize, for example, a crop regarded as an intermediate between roughage and concentrates, and which, interestingly enough, is receiving ever increasing attention in Western European countries where the conditions are more advantageous for the vegetative type of fodder production. This is all the more interesting because it means that silage maize production may make Hungary competitive in growing forage crops of vegetative type too. In this way the keeping of cows with high milking ability and requiring intensive feeding may be economical at an international level. Western Europe, on the other hand, cannot — in my opinion — give up its high level of milk production, which involves a certain demand for cereal feed, even in the long term, since this would mean that production was no longer competitive. Within certain limits milk production can be satisfactorily combined with beef production. At the same time I do not doubt that Hungary will continue to play an important role in producing animal species consuming grain feeds, particularly poultry and pigs, if no other reason than that these animal products provide high income and employment, and take the place of grain exports, which provide a substantially lower gross income. It should be added that maintaining the production of peasant farms is an important political issue, particularly in Western Europe, and is supported in many cases even if the economic efficiency is disputable from the point of view of world competition.

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PÁL, GY.: *In Hungary the number of cattle in the state farms was 208,300 in 1960, 247,300 in 1965, 229,400 in 1970, 248,000 in 1975 and 290,000 in 1979. In the same years there were 448,500, 816,200, 981,800, 1,148,000 and 1,131,000 cattle in the collective ownership of co-operative farms, while 737,800, 699,000, 526,100, 441,000 and 347,000 cattle were* *in the private ownership of members of the cooperatives. A further reduction can be expected in the number of cattle in private ownership. If the cost of providing satisfactory accommodation for the animals is also taken into consideration, will it be possible for the cattle stock of the state and co-operative farms to compensate for the rapidly diminishing cattle stock in the household plots ?*

HORN, A.: In my opinion the government decree on cattle breeding, which came into force in 1972, and which not only arranges for various subsidies to be given to cattle farms but also calls for specialization, will in many respects create a new situation in cattle production in the next few years. A gradual reduction in the livestock on household plots must definitely be expected, but there is also an irreversible tendency for farms not to undertake milk production unless they can produce about 5—7 thousand kg milk or more than 200 kg butterfat per cow a year. This will be necessary partly so that the domestic requirements for milk and dairy products can be satisfied with a stock of 5—600,000 cows, thereby reducing the extremely high investment requirements of milk production, and partly because an ever decreasing number of adequately qualified workers will be available to attend to the highly productive cattle stock. This process of specialization will not only greatly reduce the enormous investment and manual labour requirements of cattle production, but will also guarantee its competitiveness.

Other attempts at specialization include the extension of beef-cow farming, which requires practically no buildings. The main reason for this is that the large amount of roughage available in Hungary, which is not suitable for cows of high milking ability or for other animal species because of the high fibre content, can be made good use of in beef production. This is also in the interests of the national economy, as valuable products which would otherwise be wasted can be converted into high quality meat which is also suitable for export purposes. If beef cattle rearing, which has so far been ignored in Hungary, is based on the utilization of roughage which cannot be used in feeding other kinds of animals, it could definitely be made economically efficient, since it has been the subject of a great deal of research. Certain intermediate solutions might also be considered, depending on how the export possibilities and prices affect the profitability of beef production. The state and co-operative farms should be able to produce enough to compensate for the loss of the livestock now kept on the household plots.

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PÁL, GY.: *The animal husbandry technologies applied in Hungary required a great deal of fixed assets and energy. The monetary value of the machinery per worker is sometimes of the order of a million forints. At this technical level rapid changes in the type of production are no longer possible, because of the investment costs, if for no other reason. The adaptability of livestock farming and its responsiveness to new research results decrease parallel with the technical level of production. How do you think the inconsistency between the application of new research results and the technical progress of production can be resolved at the present level of investment ?*

HORN, A.: The high investment requirement mentioned above and the high rate of amortization which this involves particularly affect modern milk production and pig farming, and definitely mean that the standard of production should be raised to a very high level so as to reduce the cost per unit product, and at the same time the technology should be simplified wherever possible. Over-expensive, energy-intensive solutions, the returns of which are disputable, should not be used. Particularly the extremely costly ways in which manure is removed and the occasional over-mechanization of livestock buildings require thorough revision. Methods devised by researchers and those adopted by the production systems seem to have produced considerable progress in recent years.

*

PÁL, GY.: *Dairy farming is the most capital and assets-intensive branch of livestock production; it is therefore in the national interest to meet the domestic requirements with the lowest possible number of cows with high milking ability (giving 5—7 thousand kg of milk a year). This, however, would mean that cattle production should be specialized to dairy and beef herds instead of the present dual-purpose system of cattle production, i.e. the dual-purpose stock should be reduced and the number of dairy and beef cattle increased. In your opinion, has Hungary the economic background and breeding conditions necessary for this ?*

HORN, A.: As far as specialization is concerned, I am convinced that under the conditions in Hungarian large farms a gradual reduction in the dual-purpose cattle stock should definitely be expected. Dual-purpose cattle stock will probably be maintained longest in the small peasant farms of Western Europe. In my opinion, the conditions required for specialization have been created not only by the increase in large-scale cattle production, but also by the long decades of research and practical experience. These conditions have mostly been provided through a correct choice of breeds and the use of adequate crossing partners, so after the programme has been carried out, with the exception of a transitional period, no fall-off either in the qualitative parameters of the beef production or in the economic efficiency of production need be feared, I am definitely of this opinion, even taking into consideration all the implications of the extremely good beef production of Hungarian Simmenthal cattle.

*

PÁL, GY.: *A reasonable balance must be maintained in the purchase price structure of milk and cattle, for if the purchase price for live animals were fixed too high compared to that of milk, farms would not be interested in keeping cows and would rather sell the progeny as beef cattle. In that case the number of calves and consequently the stock of beef cattle would decrease. Do you think the current purchase prices for live animals and milk in Hungary favour beef cattle rearing or dairy farming ?*

HORN, A.: In Hungary at present a state of transition has to be maintained in the purchase prices of milk and live cattle and in the farm structure. This presents the difficulty that, since specialization is not yet complete, in addition to farms which produce about 6 thousand kg milk or over 200 kg butterfat, there are also farms where the milk production is at a very low standard (2—3 thousand kg per cow). Since, however, the national economy of Hungary cannot, for the time being, do without the milk production of farms with low productivity, the government is compelled to maintain an attractive milk price and dotation system so as to make milk production sufficiently profitable even for these farms. This solution is, of course, irrational in itself, but if the food supply to the population is to be satisfactory, it is inevitable for the time being. As soon as the proportion of farms with high productivity is sufficiently large, those which are less efficient will be gradually eliminated and the proces of specialization completed. To some extent this applies to beef production as well. As yet there are not enough farms keeping single suckler cows to take over a significant proportion of the beef production in Hungary. Research has, however, arrived at the point where it can provide the know-how for the establishment of beef production systems, which, provided the export prices are satisfactory, will make Hungary competetive in producing first quality beef cattle. It should be added that it is very important to develop the meat industry and the slaughter-house network, so that in the future as small a number of live cattle as possible need be exported. This would be important not only in order to reduce transportation costs, losses in transit and health risks, but also from an economic point of view, because the expensive transportation would be restricted to those parts of the beef for which a high price can be obtained, and at the same time the hide could be utilized by the domestic leather industry, which at present pays enormous sums for imports.

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PÁL, GY.: *The protein content of the muscular tissue is the most valuable part of the meat; this is almost completely utilized by the human organism. The more muscular tissue and the less connective tissue the meat contains, the higher its value. In addition to the protein, the fat content of the muscular tissue (marbling in beef), the essential amino acids (which the organism cannot synthesize but cannot do without) and the vitamins (vitamins S_1 and S_2 in beef) are also valuable components of meat. How much, if any, importance do you attach to the fact that in the loose keeping system the animals have 23–24% protein in the muscular tissue and only 14% in the tied keeping system ?*

HORN, A.: In my opinion differences caused by the keeping system in the amount of muscular protein do not matter very much in the case of beef, since beef consumption in Hungary is relatively low (about 10 kg per capita a year). Nor do I think an increase in beef consumption would be of primary interest to the Hungarian national economy, partly because beef has a very unfavourable transformation coefficient. Apart from this, modern husbandry systems, of which loose keeping is coming into prominence, tend to increase the proportion of musculature. Thus, up-to-date technological systems have a favourable influence on the quality of beef.

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PÁL, GY.: *In 1978 the per capita consumption of milk and dairy products, expressed in milk weight equivalent, was 304 litre/capita in Sweden, 302 in Switzerland, 297 in Denmark, 292 in France, 280 in Holland, 272 in Poland, 252 in the German Federal Republic, 239 in Austria and 212 in Czechoslovakia. In the same year the per capita milk consumption in Hungary was 152.7 litres, some 60% of the quantity considered optimum from a nutritional point of view. In your opinion, is it owing to the eating habits or to the high price of milk that milk consumption is so low in Hungary ?*

HORN, A.: The milk consumption of the Hungarian population, though not yet satisfactory, has made considerable progress in recent years. Improvements in market organization and the considerably better quality of the dairy products have undoubtedly played a part in this. I think it is very important to increase the consumption of milk and dairy products still further, particularly because, of all animal products, milk can be produced with the least transformation loss and is at the same time the healthiest and most essential food.

I am convinced that milk consumption could be increased in Hungary. The preconditions include a well organized marketing system not only in the towns but also in the country, where privately owned cows can be relied upon less and less. Furthermore, it is important to introduce regular milk consumption in schools, because if the habit of drinking milk is formed early, it will probably be maintained in adult life. Finally, the consumption of cheese, butter and cream could be considerably increased; this will certainly be favourably influenced by the recent results on nutrition research, which show that the negative effect previously thought to be exerted on health by butterfat, through an increase in the cholesterin level, cannot be demonstrated in humans healthy constitution.

*

PÁL, GY.: *Rabbit and sheep farming brought Hungary nearly 100 million dollars in foreign exchange in 1979. Ninety per cent of the rabbits are produced on household plots and subsidiary farms, while 90% of the sheep are reared in state and co-operative farms. While sheep breeding is rapidly developing, rabbit rearing has stagnated, although the prices for live rabbits and sheep sold as mutton are nearly identical: $1500/ton. In your opinion is it likely that the development of rabbit breeding is hindered by the fact that the farm price is 87% of the export price for sheep and only 67% for rabbit ?*

HORN, A.: There is definitely a disparity between the production of sheep and rabbits. A certain amount of stagnation has recently occurred in Hungarian rabbit production, though the standard is still internationally recognized. This is due partly to temporary marketing difficulties, and partly to a low delivery price combined with increased feeding costs. In my view rabbit production will be of increasing importance not only in Hungary but on an international scale too, particularly when promoting meat production in the developing countries, since rabbit breeding renders it possible to utilize fodders that man cannot make use of either himself or through other animals.

*

PÁL, GY.: *In the large-scale production of eggs and broilers rearing and fattening houses must be operated under strictly defined feeding, ecological and prophylactic conditions. Since living organisms are the object of the production process in these modern livestock farms, their requirements are more complex and require better organization of the technological processes than those of any industrial plants producing standard industrial products. As a professor of animal husbandry do you think breeders or engineers should be in the top management of such farms ?*

HORN, A.: The priority of biological or technical qualifications is a question raised today in many fields where livestock farming is carried out within technological systems. I think the problem has been made more acute due to the unfavourable situation caused by the irregular supply of spare parts and by faulty machinery. The frequent breakdowns, which in many cases create serious, almost insoluble problems in the farms, often call for immediate attention from the technical staff. In my opinion, however, this is an abnormal situation which should change once the quality of the machinery and other equipment is improved and when a regular supply of spare parts is ensured. Since the chief value of large-scale egg and broiler production is connected with living organisms, I am of the opinion that livestock breeders with a biological education, but with a feel for technology should be put in charge of such farms.

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PÁL, GY.: *Thank you for the information.*

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CHRONICA

KÁLMÁN SZÁSZ

1910—1978

With the death of Dr. Kálmán Szász on 23rd August 1978, the scientific life of Hungary, and phytochemical research in particular, met with a great loss. He gained a university doctor's degree and a C.Sc., he was an honorary assistant professor, and the holder of various medals. He played an important role in breeding medicinal plants supplying basic material for modern pharmaceutical products and in elaborating their agrotechnics, as well as in producing drugs of high purity. Agrochemistry was another field in which he was interested. His paper "Adatok a lucernagyökér tartalékszénhidrátjainak változásához" (Changes in the carbohydrate reserves of alfalfa roots) was published in the journal "Agrokémia és Talajtan" in 1963.

Kálmán Szász was born in Sepsiszentgyörgy, Transylvania, on 7th October 1910. His father was a teacher at the famous Székely "Mikó" Calvinist high school where he took his school-leaving examination in 1928. In 1934 he obtained a diploma in pharmaceutics at Bucharest University, and in 1938 a teacher's diploma in chemistry and physics at the University of Kolozsvár. From 1934 to 1936 he was employed as a chemist in the "Szent György" pharmacy in his native town, then he moved to Hungary and gained a scholarship to work at the Institute of Mineralogy of the Royal Hungarian Pázmány Péter University, Budapest. From 1939 to 1944 he was head of the analytical laboratory in Dr. Wander's Pharmaceutical and Dietetical Works, Budapest. In the middle of 1944 he was ordered to work in the pharmacy in Nagysomkút (Szatmár county), then he did military service in the No. 11 military hospital, and was taken captive with his unit.

After the end of the war, from 15th November 1945, he became manager of the "Plant Unit" of the Chemical Works of Gedeon Richter, Ltd., then from 1953 to 1975 he headed the "Phytochemical Research Laboratory" of the same company. As a chemist, he carried out thorough studies on medicines prepared from the extracts of medicinal plants, following the material from the selection of the soil and germ, through cultivating and breeding, up to the drug, until it became an effective medicine. He was engaged in elaborating an up-to-date method of utilizing the active substances of two important medicinal plants, *Digitalis lanata* and *Claviceps purpurea*. His first success was the crystallization of "Neoadigan" from *Digitalis*. He always worked in co-operation with the breeder, the agricultural experts, and with his colleagues in the laboratory. With his wide knowledge, he modernized the manufacture of Hungarian drugs of vegetal origin. Isolating a hypotensive alkaloid from *Vinca minor* L., he prepared the pharmaceutical products Vincamin and Devincan; the drug Cavinton^{R} was a later version of the latter. Another field of research he shared with his colleagues, was the production of vinblastine and vincristine, two alkaloides suitable for the medical treatment of neoplastic diseases, particularly in leukaemia; these were isolated from *Catharanthus roseus*. Two products, Vinblastine and Vincristine, were put on the market by the factory as a result of this work.

His mind, rich in ideas, was always searching for innovation; he applied all his theoretical and scientific discoveries to industrial practice in order to make them useful to the sick and profitable for the national economy. His first important invention was the U-shaped vibration extractor, the licence of which was bought and applied in many countries (including the United States of America). He was granted patents for 11 further inventions, in which his closest colleague Csaba Lőrincz had a great share.

His C.Sc. thesis (1965) was entitled "A diffusiós folyamatok vizsgálata gyógynövények oldószeres kivonatolásánál" (Study on diffusion in medicinal plants extracted with solvents). As an acknowledgement of his work, the government awarded him the silver (1967) and gold (1975) medal of the Order of Labour.

In the lectures he delivered at the Budapest and Szeged universities as a titular assistant professor he was the first to make the students acquainted with modern pharmaceutical production technology. His seminars were a source of great attention and interest. He spoke English, French, German, Russian and Roumanian, and also published in all these languages. Nearly fifty scientific works appeared in Hungarian and foreign journals. His vast knowledge was internationally recognized.

He was a frank, friendly person. Fatigue or obstacles were unknown to his puritan character. He was fond of saying: "the affairs of life should be put in their place". He did his utmost to carry out this aim. His colleagues not only respected him but were also very fond of him; he was very popular.

He earned distinction as an excellent Pharmacist (1960) and was honoured three times with the title of Prominent Worker and twice with that of Prominent Inventor (1969, 1973). He was most proud, however, of the Vince Wartha medal received from the Hungarian Chemists' Association, and of the János Kabay medal presented to him by the Hungarian Pharmaceutical Society, because these were the signs of recognition by his colleagues.

This necessarily brief summary of the life and work of Kálmán Szász was written as a memorial to the outstanding Hungarian scientist.

L. Hegedüs

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AS I SEE IT...

RELEVANCE OF BIOCHEMISTRY FOR AGRICULTURE AND FOOD PRODUCTION

One has to be aware of the difficulty of looking for the role of a single discipline in the development of a complex activity. It is rather like watching a football game, but only following the performance of a single player, forgetting all about the others. The actions of a single player, whether he is running or standing idle appear senseless (and ridiculous) in themselves; one can only appreciate the value of a player if one looks at interactions and if one looks at the game as a whole. Nevertheless, I think it is worthwhile saying a few words on the relevance of biochemistry in agriculture, because I believe that in this game of trying to achieve better results in food production, biochemistry is still standing somewhat idle on the sideline, whereas just now there is a need to involve it in the field where decisive action is anticipated.

Historically, for more than a century, biochemistry has played an important role in the development of the medical sciences. It is understandable that, in the view of the layman, the main task of science in the field of biology should be the conquest of diseases. The study of the composition of the body, the analysis of metabolic changes and the understanding of the role of biochemical processes in biological functions have contributed a great deal to the progress of diagnostics and to the evolution of the pharmaceutical industry. In Hungary, too, biochemistry was considered for a long time to be an exclusively medically oriented discipline, and it is only recently that biochemistry departments have gained acceptance in other faculties.

If we look at contemporary biochemistry through the many thousands of pages of scientific literature, we can see that, although most of it is still medically oriented, an increasingly greater fraction of the literature deals with biological chemistry in general, not directly related to medical problems. The study of gene action and manifestation, of cell membrane phenomena and of the mechanism of cell division and differentiation is performed by biochemical techniques, using as objects bacteria, moulds, algae, etc. Sometimes this broadening of the number of biological objects is regarded as a sign of "autotelic" biochemistry (or biology), i.e. as the inherent trend of "pure science". Indeed, it is true that differentiation studies, for instance, have achieved much through the study of the life cycle of a brown slime mould (Diotyostelium discoideum), because the factors influencing the reprogramming of its metabolism in a changing environment can be studied more easily than the differentiation in an eukaryotic cell culture or in oocytes. However, I doubt if this can be taken to support the concept of an internal driving force of science, the concept of "science as intellectual enterprise, just for the sake of scientific curiosity".

The overriding importance of economic development in the determination of the uneven development of different branches of science has been pointed out by contemporary philosophers. This does not in any way imply subscribing to a utilitarian use and role of science. It means that we recognize the role of physics and chemistry in the rapid development of technology during the past century. It means that we recognize the driving force in developed societies to further research in biology. Some developed nations now believe that in the "post-industrial" phase the taxpayers' money should rather be used to prevent cancer and to provide sophisticated health care for people whose food and other material needs are ensured.

I am convinced that at the present moment we should observe the trends and then make our own decisions, instead of simply assuming that the best thing for us is to follow the trends in the most developed nations. If we agree that trends of sciences are determined by social needs, including the trend of "pure science", then the trends cannot be the same for different nations. I believe that for us the progress of biology should also be used to further agriculture and the food industry, while at the same time we must keep up with new lines of biology in support of medicine. In any case, the progress of Hungarian agriculture depends more on our own scientific efforts related to specific agricultural problems, than does the development of medical sciences, which can be taken over much more easily from international advances in sciences. In addition I would like to mention that another thought is lingering at the back of my mind: for mankind in general the development of health care should be parallelled by the development of food production, in order to avoid the threatening imbalance between population increase and food reserves.

When I maintain that biochemistry (and biology in general) should turn its attention more to problems of agriculture and food production, this is not sterile wishful thinking, because contemporary biochemical (and biological) research has in fact reached a stage where it promises to revolutionise techniques in agriculture and animal husbandry. One cannot deny that the 20th century has brought great progress in agriculture and food processing, based on scientific knowledge gained a few decades ago. What I maintain is, that the scientific-technological revolution has not yet really touched agricultural practices. We are at a turning point right now, when it is possible to initiate entirely new methods and not only steady improvements.

One more reservation, before outlining my prognosis for the relevance of biochemistry in food production: there is a close interdependence between the progress and the application of biochemistry and other branches of molecular biology. Nowadays there are very few research lines which can remain within the domain of biochemistry proper (or any other isolated discipline). There are, rather, biological problems of scientific interest, in some of which biochemistry may play a decisive role, while in others, although it is a necessary component, in itself it is not able to answer all the questions. Therefore, the relevance of biochemistry is mostly one facet only of the relevance of biology.

Some specific examples

1. The staple crops of mankind are well established. One may argue that thousands of years of experience could not have missed any plant which is suitable for agriculture. Nevertheless, radical changes in knowledge and practice may lead to the introduction of new, hitherto unutilized plants as food or fodder. The biochemical characterization of many species of plants from this point of view is still ahead of us. In fact, biochemical characterization is at present the only means for characterizing gene pools and will remain so for a long time to come. This will fairly rapidly displace the predominantly morphological characterization of the species. The optimal use of genetic resources depends ultimately on many complex factors, but the original characterization and cataloguing of possibilities is a task for biochemistry.

2. A more direct and more urgent need is to apply the above mentioned biochemical characterization as a tool, and even as a goal, for plant breeding. Wheat, rice, maize and other crops are bred nowadays for such characters as yield, ecological adaptability, and some fundamental characters such as disease resistance, baking quality, etc. I believe that food (and feed) quality could become of prime importance, if we look at the problem of using vegetable products and grain for human consumption, but it is of equal importance if we think of the improved utilization of fodder. The protein quality question comes to mind first: nowadays we already have adequate biochemical methods, and a rough idea of their evaluation, for determining protein quality on large series of samples. It is my conviction that a century of plant breeding based on scientific knowledge, but with not much attention paid to nutrient quality, has rather suppressed the genetic background acting in the direction of protein quality. But this may still be recovered if — using biochemical methods — we make an effort to breed plants using protein quality as an additional marker.

3. Modern molecular biology has made great advances in the study of photosynthesis, using algae and bacteria along with the most appropriate plants. The application of this knowledge, the biochemical characterization of the photosynthetic efficiency in crops, could lead to a method of plant breeding involving the maximum possible utilisation of incident sunlight. Combined with cell fusion techniques, good progress could be made in this line by using (and advancing) our biochemical knowledge related to photosynthesis.

4. Some knowledge is already available on the development of plant tissues, but this is far behind the knowledge gained on animal model systems. Biochemistry alone will not help us in this field; the advances of morphology, genetics and other disciplines are also needed. But again, biochemical characterization of the factors involved is a prerequisite to influence morphogenesis to direct growth, root development, flowering and seed formation. There are

some indications that in the cultivation of fruit trees we can do much better in the future then with present day technology. There are good prospects for using chemicals — based on biochemical knowledge — not only for defoliation, but also for the ripening of fruits.

5. The recognition of how limited many of our resources are has led people to regard agriculture, aquaculture and forestry as prime examples of ways for obtaining renewable resources. However, this is true only in the limited sense that the energy of the sun is always available to be better exploited, whereas fresh water, N-sources, other nutrients and uneroded soil are only at our disposal in a limited way.

Therefore, in agriculture and animal husbandry we are forced to think about the reutilization of wastes such as straw, stalks, leaves, manure and the by-products of the food industry. Here again, biochemistry, along side with microbiology, must be called in to evolve an entirely new technology.

The branch of biochemistry vaguely called "fermentation" comes to mind as the first possibility of finding practical and economic methods of reutilising the by-products of agriculture and the food industry, which are increasing in volume year by year. Microbiological fermentation may be used to transform these wastes into a single cell microbial mass or to produce biogas. There are, however, a number of other possibilities. Research on cellulase enzyme complexes has already begun with a view to obtaining fodder rich in digestible sugars from wood pulp or straw. Some researchers are speculating about the use of such an enzyme system by using genetic engineering methods to transfer the appropriate genes into bacteria more amenable for technical use. Others are more inclined to see agricultural wastes as a source of alternative fuel sources, while yet others believe that these could be better used as a source of feed to produce animal proteins or even as food for human consumption.

6. A somewhat related biochemical problem, that of nitrogen fixation, is under vigorous study in many places. Apart from soybeans and a limited number of other species, we know very little yet about the possibility of utilizing biological nitrogen fixation to increase agricultural production. We may not be rich enough in fossile energy to be able to continue manufacturing nitrate for the needs of future generations. Biological nitrogen fixation certainly "wastes" a good deal of the assimilated photosynthetic energy, yet relying more on the sun is a way out of some of our difficulties. Here again, a detailed knowledge of the biochemistry of nitrogen fixation and nitrogen metabolism combined with genetic advances is expected to suggest ways to utilise better the cheapest of all raw materials, atmospheric nitrogen.

7. Biochemistry, as applied to the physiology and ecological behaviour of plants, will yield new results in studying the change in the metabolism with changing environmental temperature. None of the other higher organisms are able to react with such resilience to rapid changes in ambient temperature. The essence of this adaptation is based on the genetically determined control of the metabolism, which changes the surface of cells and tissue organelles in an appropriate way. Frost and cold resistance are improved by selection for this property, but there is also the possibility of using temporary protective measures to avoid irreversible damage. This, however, requires a specialized study of the lipid metabolism (above all, the bioregulation of the lipid metabolism). It is the adjustment of the lipid composition in the cell membranes and of the waxes at the outer surface which basically ensures the optimum survival of plants at different temperatures — within certain limits. What biochemistry offers us, is the extension of these limits.

I shall not deal here in detail with new possibilities of using biochemical methods in the food industry. The processing of foods has always been a biotechnological process based on thousands of years of experience. From the heuristic use of unknown microorganisms to prepare beer, bread and cured preserved food, we have gone over to the phase of using enzymes and/or enzyme inhibitors for the processing of food, though all the possibilities have not yet been exploited.

There is, I believe, an ever greater need at present to bring together agricultural and biological researchers in relevant fields in order to provide a channel which will make appropriate use of the information available. The interaction through a channel of information should always be reciprocal; new achievements in biology must be confronted with the problems to be solved. On the other hand, for the advancement of many biological sciences the problems of agriculture and the food industry will, I believe, provide the driving force to an ever greater extent.

The fate of a prognosis is never very bright, unless one incorporates into the prognosis facts which are already known by the writer but not by the reader. Therefore, the examples given above with respect to the possible role of biochemistry should be taken not as a programme but as a list of some possibilities. Science being what it is, nobody would be surprised if an unexpected new discovery through an unlisted item gave an entirely new direction to the future of agriculture. Molecular biology has shown very rapid growth for the last thirty years, leading to new ideas and new possibilities. Whether agriculture will be able to apply those listed above or other hitherto unnoticed ideas, will be a measure of the imagination of the author, in itself a question of no importance. The only important message is that scientific research in biology and agricultural practice aimed at food production should pay more attention to each other in the future.

F. B. Straub
Institute of Enzymology, Biological Research Centre
of the Hungarian Academy of Sciences

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LECTIONES

IRRIGATION WATER QUALITY AND PROBLEMS OF SOIL SALINITY*

I. Introduction

The growing demand for food and for raw materials produced by agriculture makes the extension of irrigation imperative all over the world. The development of irrigation is particularly important in arid and semi-arid countries, where in most cases, in contrast to rain-fed agriculture, the water supply indispensable for plant production can only be assured by adding water artificially during the vegetation period.

Unfortunately, in arid regions where the shortage of water prevents agricultural development, soluble substances accumulate regularly in soils and waters due to geochemical, hydrological and other environmental conditions; in other words salinity appears. For this reason, in arid regions whenever irrigation is planned, executed or developed, we are practically always confronted with salinity problems.

The interrelationship between irrigation water quality and soil salinity has eminent importance whenever the so-called secondary salinization of irrigated areas is concerned. This phenomenon — as old as irrigated agriculture itself — is well-known in arid and semi-arid countries and according to the data of the U.N. affiliated agencies, primarily UNESCO and FAO, more than 50% of the irrigated lands in the world is exposed to secondary salinization, alkalization and waterlogging. In order to combat these adverse processes a thorough knowledge of their properties and the causes of their formation is necessary, making it possible to predict and prevent their appearance or to arrest or diminish their harmful effect if they have already occurred.

The new achievements which have been gained in the field of research on salt affected soils on the one hand and of irrigation water chemistry on the other hand enable us to select the appropriate methods of irrigation and drainage in arid countries, to prevent the formation of secondary saline and/or alkali soils, or reduce the hazard to a negligible level.

The solution of problems arising in the field of irrigation has special importance, and a great deal of local environmental and economic information is necessary in order to elaborate a system for predicting and combatting the salinization, alkalization and waterlogging of irrigated territories or those to be irrigated. However, overall rules based on the achievements of soil science can be delineated for the characterization of the interrelationship between irrigation and salinity. When this knowledge is applied it is possible to assess a given salinity problem and determine the adequate irrigation water quality requirement.

II. Saline and alkali soils (Salt affected soils)

It is generally accepted that water soluble salts, particularly the sodium salts, are responsible for the low fertility of salt affected soils. Saline or alkali soils are those where the salt content (or the ions) interferes with the growth of the majority of crops.

In the course of the development of soil science and soil classification, two main groups of these soils have been distinguished: 1. Soils affected by neutral sodium salts (mainly sodium chlorides and sodium sulphate). 2. Soils affected by sodium salts capable of alkaline hydrolysis (mainly $NaHCO_3$, Na_2CO_3 and Na_2SiO_3).

* Lecture held at the Symposium on "Water and Fertilizer Use for Food Production in Arid and Semi-arid Zones" November 26th—December 1st, 1979, Garyounis University, Benghazi, Libya.

Soils belonging to the first group have mainly been named saline, and those of the second group, alkali soils. These two main types differ not only in their chemical character but also in their geographical and geochemical distribution, and in their physical, chemical, physico-chemical and biological properties. The methods used for their reclamation and agricultural utilization are also different.

Although it is evident that in Nature the various sodium salts do not occur absolutely separately in soils, in most cases either the neutral sodium salts or those capable of alkaline hydrolysis exercise a dominating influence on soil forming processes and soil properties.

Accordingly, in the approach to defining the units of the World Map of Salt Affected Soils, two classes were recognized. These are:

A) A class dominated by chlorides and sulphates. This class is to be called: saline.

B) A class dominated by exchangeable sodium and/or by sodium bicarbonate and/or by sodium carbonate. This class is to be called: alkali. This is subdivided into:

a) a sub-class without a structural B horizon,

b) a sub-class with a structural B horizon.

On various continents, under a very wide range of environmental conditions, the general levels of salinity or alkalinity of the parent materials and groundwaters may differ sharply. The salinity or alkalinity tolerance of local crops varies widely, too. The potential salinity or alkalinity of an area depends, to a considerable extent, on the cropping system used in that particular area. It is more than obvious that in all these respects only very vague limit values may be given on a worldwide scale. Therefore it is necessary, while keeping the basic principles in mind, for a certain flexibility to be displayed in the definition of salinity and/or alkalinity limit values characterizing the salt affected soils of a given territory; that is, the local conditions should also be taken into consideration.

A) Saline Soils

On most continents the dominant types of salt affected soils are the saline soils. Figure 1 shows the schematic profile of a saline soil.

For saline soils the following definition was accepted: "Soils having a saline (salic) horizon within 125 cm below the surface (125 cm in the case of coarse texture, 90 cm in the case of medium texture and 75 cm in the case of fine texture) or having an electric conductivity of more than 4 mmhos in at least some part of the soil within 25 cm below the surface; if the pH (H_2O 1 : 1) in this layer is 8.5 or less an electric conductivity of more than 15 mmhos should occur within 125 cm below the surface in the case of coarse texture, 90 cm in the case of medium texture and 75 cm in the case of fine texture."

In most cases the salt content of saline soils significantly exceeds the limit values given above.

The percentage quantity of mineral residues determined from a 1 : 5 aqueous extract is used to establish the limit values of salinity. In the USSR and in several other countries this method is used almost exclusively.

It has been impossible to find an exact correlation between the E.C. values and the data of the 1 : 5 aqueous extracts in relation to the diversity of the chemical composition of soluble substances in soils.

For a rough estimation, however, 0.25% salinity measured in the 1 : 5 aqueous extract may be considered as equivalent to an E.C. value of 4 mmhos/cm. Evidently, considerable deviation may occur in the case of different ions. If, in a given case, the determination of the exact correlation is necessary, methods for its calculation in the case of different ions and concentrations are given by Jackson (1958) and Darab—Ferencz (1969).

The maximum salt accumulation may be found at different depth in the soil profiles but very often it occurs in the top layer or near the surface. In Europe the saline soils have developed in the most arid regions. The few exceptions to this rule are caused by the salinity of local groundwaters or soil-forming substrata.

Seasonal changes caused by climate and, particularly, by irrigation and drainage may occur in the salt content of saline soils, as well as in the distribution of salts in the different layers of the soil profile. These possible changes should always be taken into consideration when the soils are described and during the sampling and analytical procedures.

The basic morphological precondition for saline soils is the lack of a structural B horizon (Fig. 1). Although several morphological systems use the letter "B", in those cases it never signifies a horizon distinguishable from the A horizon due to its well-developed structural formation. Consequently, the profiles of saline soils are rather monotonous, from the surface down to the parent material. In a few cases, when saline soils have formed under bog con-

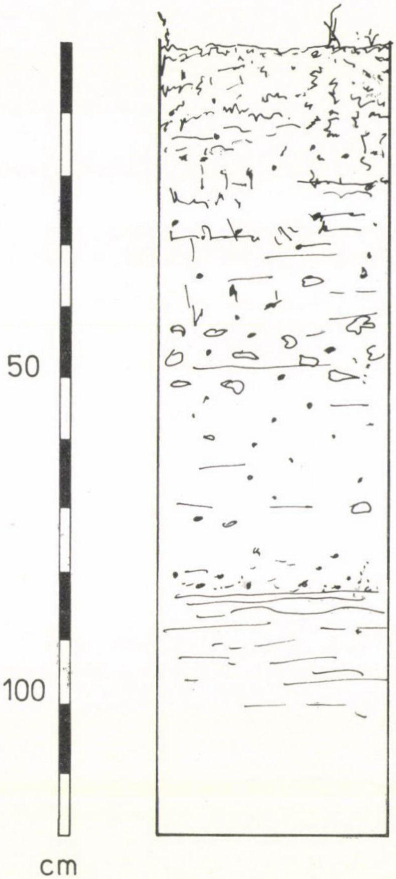

Fig. 1. Schematic profile of a saline soil

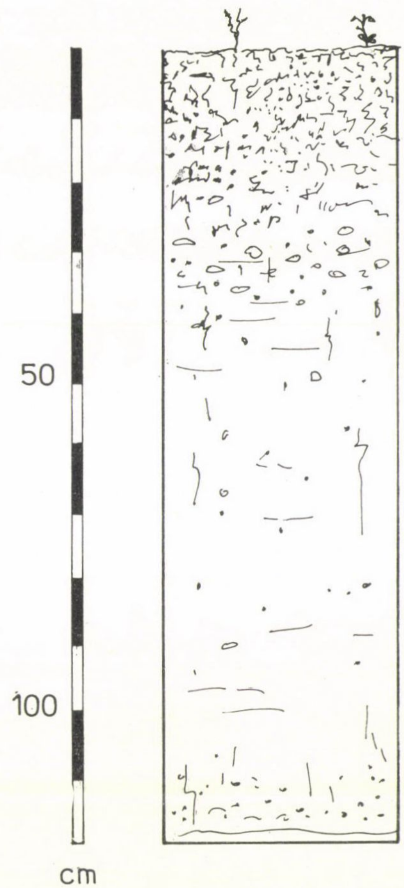

Fig. 2. Schematic profile of an alkali soil without a structural B horizon

ditions, the top layers are humous, but usually, when they have developed under arid conditions, these soils are very poor in humus substances and their humus content is lower than 1%. The low plant nutrient content (mainly N and P_2O_5) is also characteristic of most saline soils.

The high salinity determines practically all physical and chemical properties of saline soils. Consequently, when these properties are evaluated, the salt content of the soils and its influence should primarily be taken into consideration.

Many classification systems employ the term "chloride and/or sulphate solonchak" for saline soils.

B) Alkali Soils

In alkali soils the presence of Na-salts capable of alkaline hydrolysis determines the soil properties. Due to their effect either the high alkalinity of the soil solution hinders plant growth, or the alkalinity renders the physical soil properties disadvantageous for the water supply of the plants. Evidently, these processes often exert their harmful influence together, though in alkali soils without a structural B horizon the former dominates, and in alkali soils with a structural B horizon the latter dominates.

As a rule, in the case of soils belonging to sub-class *a)* (alkali soils without a structural B horizon) a fairly high concentration of water-soluble sodium salts capable of alkaline hydrolysis can be found even in the top layers. In sub-class *b)* (alkali soils with a structural B horizon) the concentration of water-soluble salts is often very low and, except in the B horizon, alkalinity may also be quite moderate. Owing to the considerable differences between the properties of soils belonging to sub-classes *a)* and *b)*, their characteristics and definitions should be discussed separately.

a) *Alkali soils without a structural B horizon*

In these soils a saline (salic) horizon can be found within 125 cm (125 cm in the case of coarse texture, 90 cm in the case of medium texture and 75 cm in the case of fine texture) below the surface, or the electric conductivity is more then 4 mmhos in at least some part of the soil within 25 cm below the surface. The pH (H_2O 1 : 1) should be more than 8.5 somewhere in the 0—25 cm thick layer. (It should be noted that if the pH is determined against phenolphthalein, a careful analytical procedure is necessary because the finely dispersed calcium carbonate also gives a slight pink colour with phenolphthalein. In such cases a more precise pH determination or titrimetrical analysis must be carried out.)

As a rule, in alkali soils without a structural B horizon a fairly high concentration of sodium salts capable of alkaline hydrolysis (mainly sodium carbonate) is found. Of all the salts which commonly occur in soils, sodium carbonate exercises the most harmful effect on both soils and plants. Thus, this sub-class represents salt affected soils which have disadvantageous properties for agriculture. Their fertility, if any, is very low. Not only the alkalinity, but in most cases also the salinity of these soils is quite high. This is why in many classification systems they are denominated "alkali-saline" or "saline-alkali" soils. Although sometimes neutral sodium salts may also prevail among the water-soluble substances in these soils, the dominant role is nevertheless played by sodium carbonate, owing to its high alkalinity.

Figure 2 demonstrates the schematic profile of an alkali soil without a structural B horizon.

Similarly to the profile of a saline soil (Fig. 1), this soil also lacks a B horizon of well developed structural elements, distinguishable from the A horizon. On the basis of this morphological similarity, in many classification systems these soils are indicated as solonchak soils. In order to distinguish them from saline soils, they are named sodium carbonate or soda solonchaks as distinct from sodium chloride or sodium sulphate solonchaks.

The percentage of sodium carbonate and bicarbonate may vary from a few tenths up to several percent in these soils. Depending on the local conditions, the salt maximum may occur at the surface or in the deeper layers. The depth of the water table differs, but in Europe the groundwater is within 2 metres of the surface in most cases. As a rule, the more we approach the moderate or humid climatic zone, the nearer the groundwater rises to the surface.

Due to the high alkalinity of these soils, the top layers are rather compact, structureless, and their extremely low water permeability or virtual impermeability is a very important factor from the point of view of drainage or chemical reclamation.

Most alkali soils without a structural B horizon are very poor in humus and plant nutrients (particularly in N and P). Humous top layers may occur, however, more often in humid or semihumid areas than in the case of desert soils, owing mainly to bog conditions or comparatively wet conditions. Especially when the soda forming processes are associated with temporary waterlogged conditions, the humus content of the top layer may reach several percent, while in other cases it amounts only to a few tenths of one percent.

Because high alkalinity is accompanied by high salinity, the former governs not only the chemical but also the physico-chemical processes in these soils. Consequently, the determination of exchangeable cations is not always necessary and quite often it may even prove analytically difficult during the survey and routine analysis of alkali soils without a structural B horizon.

b) *Alkali soils with a structural B horizon*

The definition of these soils is based on the prismatic or columnar structure of the B horizon, which is accompanied by a high percentage of exchangeable sodium ions (ESP $>$ 15).

This sub-class represents the most widespread group of salt affected soils in Europe.

In some classification systems soils belonging to this sub-class are denominated "solonetz" or "solonetz-like" ("solonetzic", "solodized", "solod", etc.) soils. There are countries where various, sometimes completely different names are used to indicate them, and even

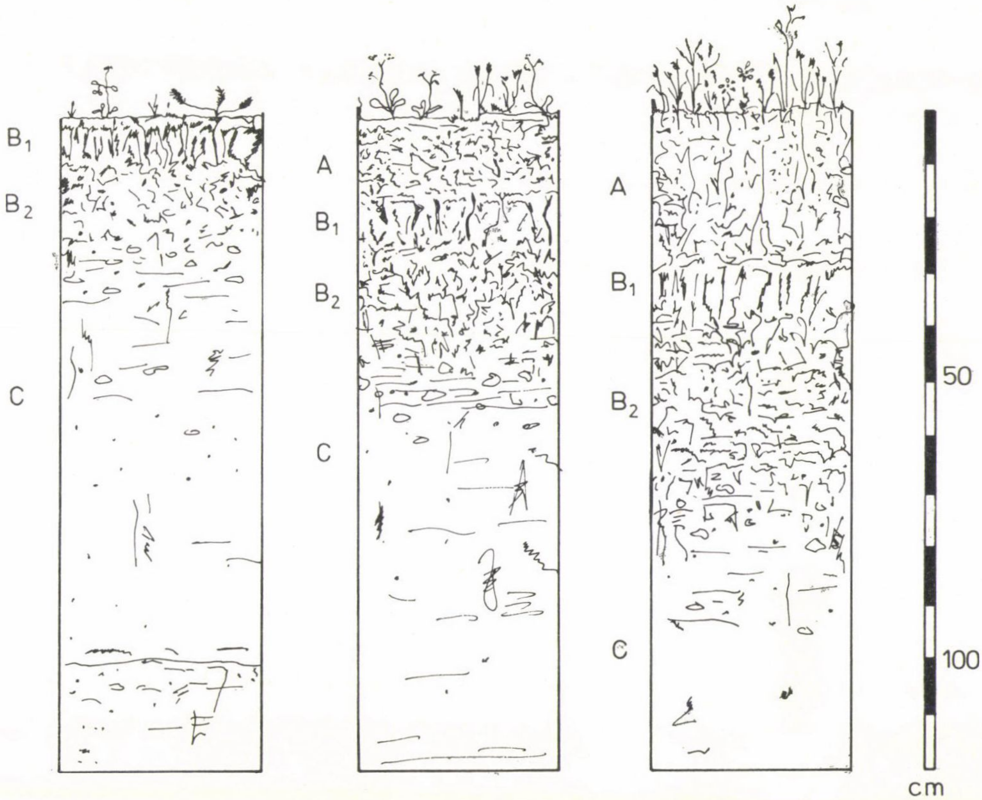

Fig. 3. Schematic profiles of alkali soils with structural B horizons (solonetz)

in the scientific literature the term "solonetz" is interpreted in many different ways, so it is necessary to summarize briefly our knowledge of the formation, morphology and properties of these soils.

In Fig. 3 schematic profiles of alkali soils with a structural B horizon (solonetz) are shown.

These soils always have a structural B horizon in their profile, which, as a rule, has a well-developed structure, mainly columnar. It can be easily distinguished from the horizon (A horizon) above it, which is less compact and the structure of which is less developed. This B horizon determines the genetic type of these soils, their main physical, chemical, physico-chemical and biological properties, and their fertility, together with the possibility of agricultural utilization.

The structural B horizon is situated at various depths, depending on local circumstances. In some cases it is at the surface (the A horizon is completely lacking) (Fig. 3a).

The structural B horizon always differs markedly from the A horizon, not only in morphology, colour and structure, but also in its physical, chemical, physico-chemical and biological properties. Figure 4 schematically represents some of the chemical, physical and physico-chemical properties of an alkali soil with a structural B horizon.

The figure demonstrates that at a given depth below the surface (in this case at about 30 cm) an illuvial horizon, i.e. an accumulation horizon, may be found. This is named B or B_1 horizon. In this horizon the accumulation of clay particles and sesquioxides may be observed and the water-soluble organic matter content as well as the ESP values show their maximum, while the ratio of $SiO_2 : R_2O_3$ is the lowest and silicon compounds are comparatively at a minimum. In Fig. 4 this horizon is between 20—30 cm, as is often the case in nature, but it

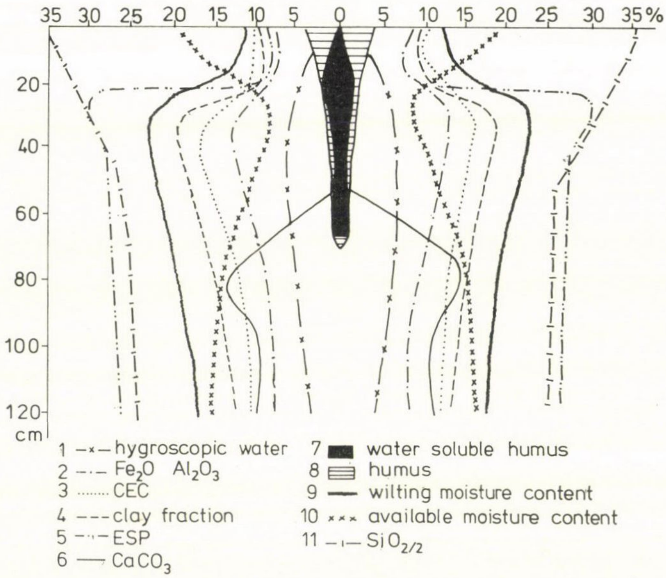

Fig. 4. Schematic representation of some of the physical, chemical and physico-chemical properties of an alkali soil with a structural B horizon (solonetz)

frequently occurs at depths other than this. Naturally, in such cases the respective maximum and minimum values are to be found at the depth where the B horizon has developed.

It may be seen in Fig. 4 that, as regards the movement and accumulation of materials, the situation in the A horizon is just the contrary. A is the eluvial horizon.

The thickness of the A horizon is a very important feature of these soils. Their fertility is in direct proportion to the thickness of the A horizons. For one thing, it determines the amount of water retained and available for plants. The B horizon is much more compact than the A and the penetration of plant roots is always impeded. In addition, as clearly shown in Fig. 4, the amount of exchangeable sodium and water-soluble sodium salts harmful to plants is lower in the A than in the B horizon.

One of the important characteristics of the B horizons of solonetz soils is their high exchangeable sodium content. It is generally considered that the high exchangeable sodium content is responsible for the poor physical and water regime properties and the compact structure of the B horizons of these soils. The exchangeable sodium content is usually expressed in me/100 g soil or, even more frequently, as a percentage of the cation exchange capacity (ESP). As was mentioned earlier, the limit value of ESP for alkali soils with structural B horizons is 15; when the ESP value is about 5—7, the first signs of the development of a compact B horizon may be observed in the profile. Naturally, the limit values are approximate and may vary slightly depending on soil properties and local conditions. The basic feature of identification for these soils is always the morphology of the B horizon described above.

Depending on local circumstances, some alkali soils with structural B horizons may have a considerable amount of water-soluble sodium salts even in the upper layers (more than 4 mmhos), while others are practically devoid of salt in the profile. Of the water-soluble sodium salts, sometimes bicarbonates and sometimes sulphates or even chlorides prevail. With regard to the maximum accumulation of water-soluble salts in the profile, as a rule it occurs in the lower part of B_2 horizons but, depending on the conditions of soil formation, it may also occur in other layers, either above or below the B horizon. The pH value of these soils may also vary to a considerable degree. In some cases a strongly alkaline pH may be observed on the surface; sometimes the pH of the top layer is neutral or even slightly acid, and there are some solonetz soils in which a strongly alkaline pH does not occur at all anywhere in the profile. In the B horizon, however, where the maximum exchangeable sodium percentage (ESP) may be found, the pH is always over 7.

III. Quality of Irrigation Water

The total amount of water on the Earth is $1.4 \cdot 10^9$ km^3. The reserves of water occur in the form of:

salty sea water	97.0 %
ice at the poles and in their surroundings	2.15%
water reserves of the continents	0.65%

The water reserves of the continents amount to $9.1 \cdot 10^6$ km^3.
They are distributed as follows:

a) ground-water and water stored in the soils	$3.5 \cdot 10^6$ km^3
b) water in the lakes	$4.9 \cdot 10^6$ km^3
c) water in the rivers	$1.4 \cdot 10^5$ km^3
d) water content of the atmosphere	$5.6 \cdot 10^5$ km^3

Irrespectively of the sources, all the natural waters of the continents contain dissolved salts. The quality and quantity of the salts depend on the origin and course of the water. Due to the excess of inorganic compounds among the salts dissolved, the natural waters of the Earth may be regarded as an electrolyte solution of mixed salts.

The ions prevailing in the natural waters are:

Fe^{3+}, Al^{3+}, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}

SiO_4^{3-}, CO_3^{2-}, HCO_3^{-}, SO_4^{2-}, Cl^{-}

Boron, fluorine ions and compounds of heavy metals may be present at low concentrations or in traces.

Among the waters of the continents, rainwater has the lowest salt content of all types of waters. The amount of salts dissolved in rainwater varies widely and depends on the distance from the sea and on the eolic deflation. It is demonstrated in Table 1.

The salt content of the surface and the ground-water is a function of the rocks prevalent at the water source, the kinds of rocks and soils over which the water flows, the climate and the pollution of the environment due to human activities. The surface water can be classified in two groups, namely:

flowing water (rivers)
stagnant water (lakes).

The salt concentration is usually less in flowing water than it is in stagnant water under the same conditions. It appears that the average concentration of salts in river water varies between 60—180 ppm, taking the means of the chemical constituents in the river waters of the world. The Ca^{2+} and HCO_3^- ions prevail. The quantities of sodium salts are low and their

Table 1

Variations in the average composition of rain collected at various stations in Victoria during the period March 1954 to December 1956

Station	Distance from ocean		Annual rainfall (mm)	Na^+	Ca^{++}	K^+	Na : K	Na : Ca
	In S. W. direction (km)	Shortest direction (km)		me/l				
Merbein	320	320	240	0.06	0.14	0.007	8	0.4
Walpeup	260	260	310	0.05	0.04	0.004	12	1.2
Seymour	240	160	550	0.03	0.01	0.003	10	3.0
Horsham	190	190	400	0.05	0.03	0.005	10	1.7
Parwan	130	80	490	0.08	0.02	0.004	20	4.0
Coleraine	80	80	590	0.10	0.02	0.005	20	5.0
Cape Bridgewater	1.5	0.8	800	0.63	0.08	0.016	40	8.0

relative amounts vary from 10—34% depending on the continents. This is demonstrated in Table 2.

The lowest average concentration of salts occurs in the river waters of Australia and South America, while it has the highest value in Europe. The ratio of sodium salts among the salts dissolved has the highest value in the rivers of Africa. The river waters in South America and Australia have residual sodium carbonate that can be calculated from the averages of the ion concentrations.

The concentration and the chemical composition are not static but are continuously changing and are influenced very much by the climate (precipitation and evaporation) of the area. Table 3 shows the characteristics of accumulation processes in Eurasia, in relation to the natural conditions.

Regarding the mineralization of river water in Eurasia, it is 0.1—0.2 g/l in forest zones and increases up to 20—90 g/l in the desert as the dryness and average temperature of the area increase.

The stagnant water of lakes is mineralized more than the river water found in the same region. In desert and semi-desert regions the mineralization reaches 300—400 ppm in the water of lakes. The chemical composition of the dissolved salts changes with the increase in the mineralization of the water. The carbonate-bicarbonate type of salinization found at a low degree of mineralization gives way to the carbonate-sulphate, sulphate-chloride types of salt accumulation with an increase in the mineralization of the water.

The mineralization of the water of both rivers and lakes shows a seasonal fluctuation but it is less in the case of flowing water and sharper in the case of stagnant water.

The salt concentration and the chemistry of the dissolved salts in ground-water are determined by the geochemical properties of the source of the water and the course over which it flows. They are also influenced by the climate and the depth of the ground-water table. Due to the influence of transpiration, evaporation and precipitation there is a zonal distribution in the mineralization of ground-water. While a deep ground-water table has no seasonal fluctuations in salt content, the salt concentration of ground-water at a higher level changes as a function of evaporation, rainfall, drainage and irrigation practices.

1. The effect of irrigation water on plant and soil

In the case of irrigation, the quality of the water is related to the effect on plant growth and soil properties. The influence of irrigation water on the plant growth and soil properties can be taken as the direct and indirect effect of irrigation water on the soil fertility.

Both the direct effect and indirect effect of irrigation water can be favourable and unfavourable.

The direct effect of irrigation is that the crop is supplied regularly with the required amount of water, thus increasing the immediate fertility of the soil.

The application of irrigation water changes the water regime of the soil and affects the salt movement and the chemical and biological reactions take part in the soil-forming process.

The irrigation water may influence:

a) the salt regime and salt movement of irrigated soils and of the soils surrounding the irrigated area
b) the sodium hazard of soils
c) the kinds and quantities of magnesium-containing compounds in the soils
d) the amount and distribution of compounds capable of alkaline hydrolysis
e) the amount of compounds toxic to plants even at low concentrations.

2. The effect of the irrigation water on the salinization of the soils

It has been shown that all waters are more or less mineralized and this has to be treated as a possible source for salt accumulation.

The effect of mineralized water on soil properties depends on whether the water is fully evaporated during and after the irrigation or whether it is partly removed from the soil layer through natural or artificial drainage.

In the first case all the dissolved salts accumulate in the soil and the soil salinity may increase considerably after a few years, even when using water with a low concentration of salts. It may happen after a single season of irrigation with saline water.

When the irrigation water is partly removed by drainage only the less soluble compounds precipitate in the soil, whereas more soluble salts will be leached out from the top soil, if water with a low degree of salinization is applied.

Table 2

Mean composition of river water of the world

	Salt concentration, mg/l	HCO_3^-	SO_4^{2-}	Cl^-	Ca^{2+}	Mg^{2+}	Na^+	K^+	RSC	SSP
		me/l								
North America	142	1.111	0.42	0.02	1.05	0.42	0.39	0.04	—	20.5
South America	69	0.58	0.10	0.14	0.36	0.13	0.17	0.05	0.095	24.1
Europe	182	1.56	0.50	0.20	1.55	0.47	0.24	0.04	—	10.4
Asia	142	1.30	0.18	0.25	0.92	0.47	0.29	—	—	14.8
Africa	121	0.69	0.28	0.39	0.63	0.32	0.48	—	—	34.3
Australia	59	0.52	0.05	0.28	0.20	0.23	0.13	0.06	0.098	21.0
World	119	0.96	0.26	0.21	0.78	0.34	0.27	0.05	—	20.8

Table 3

Characteristics of accumulation processes in Eurasia, in relation to natural conditions

Conditions	Residual salinization of sedimentary rocks	Maximum mineralization of waters (in g/l)			Max. quantity of soluble salts in top horizons of solonchaks (in %)	Typical compounds	Salinization of irrigated soils
		river	ground	lake			
Desert	common	20—90	200—350	350—400	25—75	NaCl KNO $NaNO_3$ $MgCl_2$ $MgSO_4$ $CaSO_4$ $CaCl_2$	Widespread
Semi-desert	frequent	10—30	100—150	300—350	5—8	NaCl Na_2SO_4 $CaSO_4$ $MgSO_4$	Often found
Steppes	rare	3—7	50—100	100—250	2—3	Na_2SO_4 NaCl Na_2CO_3 $NaHCO_3$	Rarely found
Forest steppes	none	0.5—1.0	1—3	10—100	0.5—1.0	$NaHCO_3$ Na_2CO_3 Na_2SO_4 Na_2SiO_3	Unknown
Forests	none	0.1—0.2	0—1	none	none	R_2O_3 SiO_2	None

The saline water may have a harmful effect in two ways.

a) The direct effect: highly salinized water can be toxic to the plant. The toxic concentration of the salt in irrigation water is rather high and a solution with a total salt concentration of 5—10 g/l can be harmful to plant growth.

b) The indirect effect: the mineralized water may have a harmful effect due to the accumulative enrichment of soluble salts in the soil after a large number of irrigations without sufficient drainage and the leaching of salts.

This is why the maximum permissible salt concentration of irrigation water varies very widely and depends on several factors. The most important factors determining the maximum permissible salt concentration in irrigation waters are as follows:

(i) The texture of the soil: in general the maximum permissible concentration of salts in the irrigation water is as high as the texture of the soil is light.

(ii) The degree of salinization in the soil and the chemical composition of the salts accumulated: if the soil is non-saline a low degree of salinization in the irrigation water can promote the accumulation of salts in the soil and an increase in the salt concentration in the soil solution. When irrigating saline soil with mineralized water the irrigation water may dilute the salt concentration in the soil solution. Some of the salts can be leached from the soil with percolating water under good drainage conditions.

The chemistry of salinization in irrigation water and soil influences the direct and indirect effect of irrigation water.

For the carbonate type of salinization the soil solution is dominated by sodium, the soil has poor water-physical properties and the salt cannot be leached without chemical amelioration. For the sulphate type of salinization calcium sulphate may be present in the soil, preventing the accumulation of sodium in exchangeable form. The saline soils are leachable in the case of the sulphate and/or chloride types of salinization. The toxic effect on crops of carbonates, chlorides and sulphates also differs.

(iii) The natural and artificial drainage conditions of the irrigated area: among the natural drainage factors the physical properties of the soil should be mentioned. These are the field water capacity, the rate of infiltration, the presence and depth of a layer impermeable to water.

The depth and fluctuation of the ground-water table considerably influence the drainage conditions and the probability of soil salinization.

The existence and effectiveness of artificial drainage systems are to be taken account when determining the limit values of salinization in irrigation water.

(iv) The salt tolerance of the plants grown and the intensity of plant production.

(v) The method of irrigation, the irrigation water norm in a growth season and the frequency of irrigation.

Due to the factors influencing the maximum level of permissible salt concentration in irrigation water it is not possible to present a uniform evaluation of irrigation water which may be utilized at all sites and under all conditions.

In the USSR the evaluation of irrigation water salinization is made as follows:

salt concentration, g/l	suitability of water for irrigation
0.2—0.5	water of best quality
1 —2	water causing salinity hazard
3 —7	water can only be used for irrigation with leaching and perfect drainage

The standard set up by the US Salinity Laboratory is shown in Table 4.

The best way to determine the maximum permissible salt concentration in irrigation water is to use the salt balance method.

Changes in the salt content of soils and the factors influencing it should be expressed as the salt balance of the soils. The salt balance of a large area, for instance of a river basin, could also be set up, but the information obtained in this way is much more definite if a smaller area, for instance an irrigated field, is considered.

When setting up the salt balance of an area, independently of its size, the following elements should be taken into account:

— total salt content of the soil at the beginning of the observation

— increase in the salt content of the soil during a given period of time.

Table 4

Grouping of irrigation water by the US Salinity Laboratory

Classification of water	Electrical conductivity (micromhos per cm at 25°C) E.C.	Salt concentration in g/l (approximate)
C1 LOW SALINITY WATER can be used for irrigation with most crops on most soils, with little likelihood that a salinity problem will develop. Some leaching is required, but this occurs under normal irrigation practices, except in soils of extremely low permeability	$0 < EC > 250$	<0.2
C2 MEDIUM-SALINITY WATER can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most instances without special practices for salinity control	$250 < EC > 750$	0.2–0.5
C3 HIGH-SALINITY WATER cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected	$750 < EC > 2250$	0.5–1.5
C4 VERY HIGH SALINITY WATER is not suitable for irrigation under ordinary conditions but may be used occasionally under very special circumstances. The soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching, and very salt tolerant crops should be selected	$2250 < EC > 5000$	1.5–3

The main sources of salt accumulation are as follows:

salty ground-water, being in close connection with the soil layer salts formed by the weathering of mineral compounds in soils the possible salt content of precipitation salt content of irrigation water.

— decrease in the salt content of the soil during a given period of time.

A decrease in the salt content may be due to the following factors:

leaching of salts by precipitation;

leaching of salts by irrigation water salt taken up by plants and loss of salts due to the harvest of the crop.

The sum of the effects of the factors bringing about a decrease and increase in soil salt content is equivalent to the salt balance of the soil for the given period and under given conditions.

Depending on the relative intensity of the factors of the salt balance, the following types of soil salt balance can be distinguished:

Stable salt balance: the soluble salt content of the soil to the depth given does not change during the period of observation.

Salt accumulation: the salt balance is positive and the salt content of the soil to the depth of observation increases during the period considered.

Leaching process: the salt balance is negative and the salt content in the soil layer under observation decreases during the period considered.

The "salt regime constant of the soil" gives the change in salt content in the soil layer to be considered when calculating the permissible concentration of salts in irrigation water due to the salt balance under non-irrigated conditions.

If the salt regime constant is positive or zero, it means that salt accumulation takes place or that the input and output of salts are the same and the salt balance is stable. In this case irrigation can be applied only after establishing a proper drainage system. If the salt regime constant is negative there is no need to leach the salt from the irrigated soil, and the limit value for the salinization of irrigation water can be calculated from the following equation:

$$d = b - \left(a + \frac{cv}{M t_{fs}} \cdot 10^{-5}\right), \tag{1}$$

where:

a = soluble salt content of the soil at the beginning of observation, g/100 g
b = soluble salt content of the soil at the last observation, g/100 g
d = salt regime constant of the soil, g salts/100 g soil
c = salt concentration of irrigation water, g/l
v = amount of irrigation water applied in the period of observation, m^3/ha
M = thickness of the soil layer considered, m
t_{fs} = bulk density of the soil.

This equation can be used to calculate the maximum permissible salt concentration in the irrigation water, or, if the salt concentration is given, to calculate the change in soil salt content due to irrigation.

In the equation the term:

$$\frac{cv}{M t_{fs}} \cdot 10^{-5}$$

is equal to the amount of salts added with the irrigation water.

For the calculation of the limit value of irrigation water salinization, the boundary condition is to assure a stable salt balance. That is,

$$a = b \quad \text{and} \quad d = \left(\frac{cv}{M t_{fs}}\right) \cdot 10^{-5} \tag{2}$$

From equation (2) the maximum permissible concentration:

$$c = \left(\frac{d\, M\, t_{fs}}{v \cdot 10^{-5}}\right) \tag{3}$$

The change in salt content to be expected if a known amount of irrigation water of a given salt concentration is applied can be calculated using equation (1) in the following form:

$$b = a + d + \left(\frac{cv}{M\, t_{fs}}\right) \cdot 10^{-5} \tag{4}$$

if: $b > a$ and "d" has a negative value, either the amount of applied irrigation water has to be decreased or irrigation water with a low concentration of salts must be used. It is possible to ameliorate mineralized water by diluting it with water having a low concentration.

$b > a$ and "d" has a positive value or is equal to zero, the drainage possibilities on the irrigated territory have to be enlarged before irrigation.

3. The effect of the irrigation water on the sodicity of the soils

The formation of sodic soils takes place only if the soil solution contains a high ratio of sodium ions. The increase in the sodicity of soils, together with the increase in the ionic concentration of the soil solution is due to two factors:

- In the case of a non-symmetrical exchange of cations with the increasing concentration of free electrolyte solution the ratio of exchangeable cations shifts in favour of monovalent ions due to the valence effect, as is shown in Table 5.
- The increase in the salt content of soils is associated in most cases with an increase in the ratio of sodium salts.

To increase the sodium saturation connected with the sulphate and/or chloride type of salinization, a highly concentrated soil solution and a high ratio of sodium salts are necessary. The accumulation process is not connected with an increase in the degree of dispersion of the clay particles. The pH value of the media remains neutral or slightly alkaline. If the soil solution is dominated by sodium carbonate and sodium bicarbonate, a high degree of sodium

Table 5

The amount of exchangeable sodium in bentonite-NaCl – $CaCl_2$ solution systems. The ratio of bentonite to solution = 1 : 100

I mol/l	$[Na^+]$	$[Ca^{2+}]$	$\frac{[Na^+]}{[Ca^{2+}]}$	$\frac{[Na^+]^2}{[Ca^{2+}]}$	$\frac{\gamma Na^{+2}}{\gamma Ca^{2+}}$	Exch. Na	CEC	ESP
	mol/l · 10^3					me/100 g		
$5 \cdot 10^{-3}$	4.6	0.14	32.62	0.15	1.179	16.03	96	16.7
$7.5 \cdot 10^{-3}$	7.1	0.23	31.21	0.22	1.223	23.00		23.9
$1.0 \cdot 10^{-2}$	9.2	0.28	32.91	0.30	1.262	28.20		29.4
$2.5 \cdot 10^{-2}$	21.9	0.71	30.95	0.68	1.444	38.07		39.7
$5.0 \cdot 10^{-2}$	41.3	1.52	27.26	1.12	1.682	50.85		53.0
$2.5 \cdot 10^{-5}$	1.89	0.11	18.6	0.03	1.123	8.5	96	8.9
$5.0 \cdot 10^{-3}$	4.31	0.18	24.7	0.10	1.179	12.0		12.5
$7.5 \cdot 10^{-3}$	7.04	0.26	26.9	0.19	1.223	15.15		15.8
$1.0 \cdot 10^{-2}$	9.09	0.35	25.7	0.24	1.262	16.45		17.1
$2.5 \cdot 10^{-2}$	21.90	1.06	20.7	0.45	1.444	25.15		26.2
$2.5 \cdot 10^{-3}$	2.06	0.11	18.6	0.04	1.123	4.23	96	4.4
$5.0 \cdot 10^{-3}$	4.31	0.23	18.9	0.08	1.179	7.70		8.0
$7.5 \cdot 10^{-3}$	6.52	0.34	18.9	0.13	1.223	9.78		10.2
$1.0 \cdot 10^{-2}$	8.26	0.51	16.4	0.13	1.262	11.82		12.3

Table 6

The amount of exchangeable sodium in bentonite-Na_2 – $CaSO_4$ solution systems

I mol/l	$[Na^+]$	$[Ca^{2+}]$	$\frac{[Na^+]}{[Ca^{2+}]}$	$\frac{[Na^+]^2}{[Ca^{2+}]}$	$\frac{\gamma Na^{+2}}{\gamma Ca^{2+}}$	RNa	CEC	ESP
	mol/l · 10^3					me/100 g		
$5 \cdot 10^{-3}$	2.60	0.10	25.7	$6.69 \cdot 10^{-2}$	1.165	11.8	96	12.3
$7.5 \cdot 10^{-3}$	3.94	0.18	22.4	$8.82 \cdot 10^{-2}$	1.208	13.8		14.4
$1.0 \cdot 10^{-2}$	5.48	0.26	21.3	$11.68 \cdot 10^{-2}$	1.332	21.7		22.6
$2.5 \cdot 10^{-2}$	13.30	0.61	21.9	$29.18 \cdot 10^{-2}$	1.416	26.5		26.5
$7.5 \cdot 10^{-2}$	3.94	0.13	31.0	$12.22 \cdot 10^{-2}$	1.205	20.9	96	20.9
$1.0 \cdot 10^{-2}$	5.30	0.18	30.3	$16.05 \cdot 10^{-2}$	1.242	21.7		22.6
$2.5 \cdot 10^{-2}$	13.90	0.48	29.0	$40.25 \cdot 10^{-2}$	1.421	33.8		35.2
$5.0 \cdot 10^{-2}$	30.40	0.98	31.0	$94.3 \cdot 10^{-2}$	1.678	51.9		54.1

saturation can be achieved at a relatively low concentration of the soil solution. In the case of sodium carbonate salinization even the accumulation period may be connected with an increase in the degree of dispersion of the soil particles and with the actual and apparent increase in cation exchange capacity, which are represented in Tables 6 and 7 and Fig. 5.

During the leaching process the decrease in the ionic concentration of the soil solution and the subsequent decrease in the ratio of sodium salt concentration promote the release of exchangeable sodium and its substitution with calcium and magnesium ions. This, however is counteracted by the fact that as the concentration of the soil solution decreases, the swelling

Table 7

The amount of exchangeable sodium in bentonite-Na_2CO_3 solution and illite-Na_2CO_3 solution suspensions

Exchanger	Solution	I mol/l	pH	Alkali-nity	Na+ me/l	$\frac{\gamma Na^2}{\gamma Ca}$	Exch. Na me/l	CEC	ESP
Bentonite	Na_2CO_3	$2.2 \cdot 10^{-3}$	8.9	1.03	1.04	1.1144	0.73	96	0.73
		$5.0 \cdot 10^{-3}$	9.4	3.93	3.56	1.1787	5.38		6.00
		$6.2 \cdot 10^{-3}$	9.3	5.70	5.22	1.2006	12.10		13.00
		$7.9 \cdot 10^{-3}$	9.6	6.95	6.95	1.2301	19.05		20.00
		$2.1 \cdot 10^{-2}$	10.0	20.52	16.54	1.4041	46.13		48.00
		$4.7 \cdot 10^{-2}$	10.1	39.75	38.26	1.6503	89.76		94.00
Illite	Na_2CO_3	$1.03 \cdot 10^{-3}$	7.8	1.03	0.95	1.1609	0.34	20	1.70
		$5.04 \cdot 10^{-3}$	9.6	4.36	4.43	1.1795	3.36		17.00
		$7.42 \cdot 10^{-3}$	10.0	6.44	6.26	1.2218	9.30		47.00
		$9.75 \cdot 10^{-3}$	10.0	8.31	9.13	1.2581	10.71		54.00
		$2.46 \cdot 10^{-2}$	10.2	22.39	20.86	1.4402	14.84		74.00
		$5.33 \cdot 10^{-2}$	10.4	45.19	44.34	1.7107	16.76		84.00

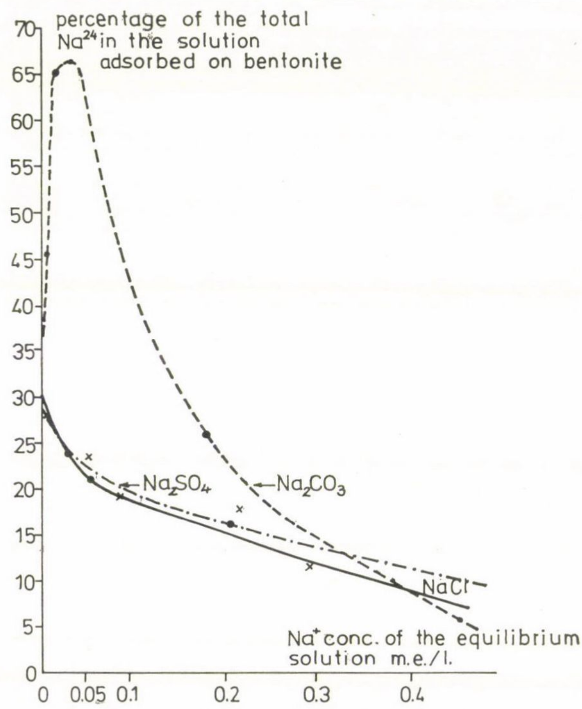

Fig. 5. **Dependence of bentonite Na-24 activity as a percentage of total Na-24 activity on the equilibrium Na+ concentration in bentonite —NaCl; —Na_2SO_4; —Na_2CO_3 solution systems**

Table 8

Classification of natural waters according to the anion composition of dissolved salts

The chemistry of water	$\frac{[CO_3^{2-}] + [HCO_3^-]}{\Sigma \text{ anion}}$	$\frac{[SO_4^{2-}]}{\Sigma \text{ anion}}$	$\frac{[Cl^-]}{\Sigma \text{ anion}}$
Hydrocarbonatic	0.5 –1	<0.25	<0.25
Hydrocarbonatic-sulphatic	0.5 –1	0.25–0.5	<0.25
Sulphatic-hydrocarbonatic	0.25–0.5	0.5 –1	<0.25
Sulphatic	<0.25	0.5 –1	<0.25
Hydrocarbonatic-chloridic	0.5 –1	<0.25	0.25–0.50
Chloridic-hydrocarbonatic	0.25–0.5	<0.25	0.50–1.00
Sulphatic-chloridic	0.25	0.5 –1	0.25–0.5
Chloridic-sulphatic	<0.25	0.25–0.5	0.5 –1.00
Chloridic	<0.25	0.25	0.5 –1.00
Hydrocarbonatic-chloridic-sulphatic	0.25–0.5	>0.25	0.25–0.5

ability and the selectivity of the adsorbent for sodium ions increase. This means that during leaching the soil becomes temporarily sodic and alkaline.

If the leaching takes place as part of irrigation or soil amelioration, the change in the chemistry of the irrigated soils interacts with the chemistry of the irrigation water.

One of the most important consequences of the long-term effect of irrigation water on soil chemical properties is the influence on the ratio of exchangeable cations. The consequence can be either positive or negative, i.e. it can increase or decrease the ESP values of soils. The effect is determined by the degree of sodicity in the soil before irrigation and by the total salt concentration and chemistry of the irrigation water.

When evaluating the suitability of water for irrigation, in addition to the degree of salinization, the type of salinization, the sodium hazard and the concentration of residual carbonate have to be taken into account. The chemistry of water salinization is characterized by the anionic composition of the salts dissolved in the irrigation water, which is shown in Table 8.

The sodium hazard can be expressed in terms of the soluble sodium percentage:

$$SSP = \frac{[Na^+]}{\Sigma\,[\text{Cation}]} \cdot 100$$

[ ] = the concentration of cations in me/l. 60% is given as a limit value for SSP by some authors. In Hungary it varies between 35 and 50%, depending on the chemistry of the water and it goes up to 60–65% in the case of sodic soil, as demonstrated in Figs 6 and 7.

Wilcox submitted a diagram illustrating the relation between the sodium hazard and the suitability of water for irrigation, which is shown in Fig. 8.

The sodium hazard of the irrigation water is evaluated through the sodium adsorption ratio in the system elaborated by the staff of the US Salinity Laboratory.

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$

The evaluation of water on the basis of SAR is also related to the total salt concentration, measured as electrical conductivity (EC) and expressed in micro-Siemens (microhmos). Four groups are indicated: low, medium, high and very high. For EC = 100 mmhos the dividing points are at SAR values of 10, 18 and 26, and for EC = 750 mmhos the dividing

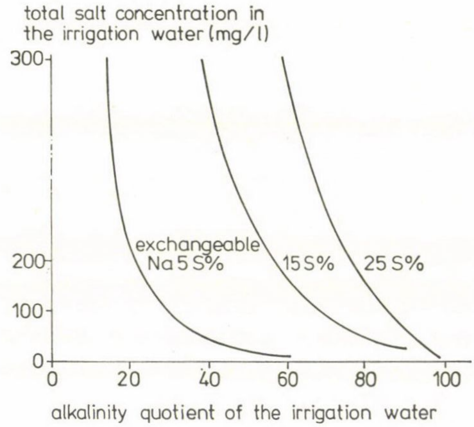

Fig. 6. Graphical form of the Gapon equation

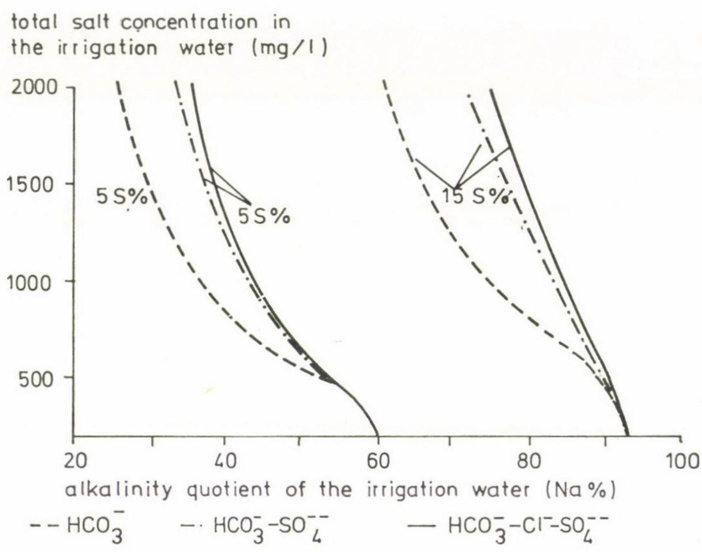

Fig. 7. Application of the Gapon equation to different types of waters

points are at SAR values of 6, 10 and 18. The relation is derived from the well-known Gapon equation:

$$\frac{RNa}{RCa + RMg} = K\frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

where:

RNa, RCa, RMg = the amount of exchangeable Na, Ca, Mg ions in me/100 g
[ ] = the concentration of cations in me/l
K = "exchange constant", which varies between 0.01–0.015.

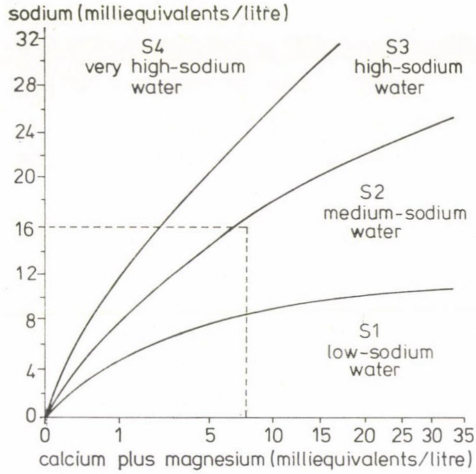

Fig. 8. Sodium diagram

It is disputable if the sum of the calcium and magnesium ion concentrations should be applied when evaluating the sodium hazard of water. It is more probable that the exchange processes are:

$$RCa + 2\,Na^+ \rightleftharpoons 2\,RNa + Ca^{2+}$$
$$RMg + 2\,Na^+ \rightleftharpoons 2\,RNa + Mg^{2+}$$
$$RCa + Mg^{2+} \rightleftharpoons RMg + Ca^{2+}$$

and that they occur parallel to one another and have to be taken into account separately.

a) *Bicarbonate hazard*

The bicarbonate hazard of water can be expressed by the value of residual sodium carbonate (RSC). The RSC evaluates the tendency of irrigation water to form carbonates and to dissolve or to precipitate calcium, and to a lesser degree, magnesium carbonates. The precipitation of poorly soluble carbonates increases the sodium hazard of the irrigation water and as a result increases the sodicity of irrigated soils, too. In this connection special attention should be paid to alkaline, low concentrated irrigation water. The RSC term can be calculated as follows:

$$RSC = (CO_3^{2-} + HCO_3^-) - (Ca^{2+} + Mg^{2+})$$

where the ion concentration is expressed in me/l. Limit values of RSC are as follows:

RSC $<$ 1.25, water suitable for irrigation

RSC $=$ 1.25–2.5, water considered as marginal; the suitability depends on the soil properties to be irrigated

RSC $>$ 2.5, water not suitable for irrigation.

In Hungary it has been shown that the evaluation of RSC values in irrigation water depends on the soil to be irrigated. Alkaline irrigation water with a measurable RSC may increase the sodicity of soil unsaturated with cations. The same water may ameliorate soil with high sodicity. The amelioration of low concentrated alkaline water with gypsum is carried out on the basis of a calculation of the concentration of residual sodium carbonate.

The bicarbonate hazard is evaluated newly by the introduction of the p_{HC} value. The p_{HC} value is calculated according to the following equation:

$$p_{HC} = (p'_{K_2} - p'_C) + p\,(Ca^{2+} + Mg^{2+}) - p_{Alk}$$

where:

p'_{K_2} = the negative logarithm of the second dissociation constant of carbonic acid calculated from the ion concentration

p'_c = the negative logarithm of the concentration product of Ca^{2+} and CO_3^{2-} ions
$p(Ca^{2+} + Mg^{2+})$ = the negative logarithm of the concentration of alkali earth metal ions
p_{Alk} = the negative logarithm of the total alkalinity in the water
p_{HC} = value indicating the tendency to dissolve from the soil if it is below 8.4 and the tendency to precipitate lime from the water applied if it is above 8.4.

b) *Magnesium hazard of irrigation water*

The magnesium concentration of irrigation water is sometimes regarded as one of the important criteria of its suitability for irrigation. Magnesium salts easily soluble in water have toxic effects on the plant and the toxicity of magnesium ions is higher than the toxicity of sodium ions at the same concentration.

Opinions differ as to the effect of the enrichment of magnesium in soils. The reason for the different results and opinions is that different types of soils with high magnesium contents have been investigated and results referring to one or other type of soil were generalized. Investigations show that an exchange of cations may take place between the magnesium of micelar and intermicelar solutions and the exchange process may take place by the isomorphic substitution of cations in the lattice layer and the micelar solution. This means that minerals rich in magnesium (montmorillonite, chloride) form during the accumulation period and the magnesium of the crystallic layer passes into the micelar solution due to leaching, thus leading to the development of layer silicates with high swelling ability, as shown in Table 9.

Table 9

The form and quantities of magnesium compounds in a meadow solonetz soil

Profile B 29 Depth of sampling, cm	Particles size fraction ∅ 1 μ, %	Total Mg		Colloid Mg		Exch. Mg	Soluble Mg
		g	me	me	me	me	
		100 g soil		100 g clay	100 g soil	100 g soil	
8– 16	53.52	0.965	79.37	69.44	37.17	17.12	0.30
26– 37	60.44	0.995	81.85	71.93	43.47	30.30	0.24
48– 55	53.72	0.488	40.18	65.48	35.17		0.31
75– 85	39.22	1.038	85.32	79.37	31.13		2.84
94–105	40.62	0.935	76.89	77.38	31.43		2.52
117–126	39.17	1.792	147.33	71.93	28.17		0.85
135–145	42.29	1.249	102.70	81.35	34.40		

Taking into account the direct and indirect influence of magnesium on soil fertility the magnesium hazard is considered as one of the criteria for the suitability of water for irrigation. The magnesium hazard is expressed as the ratio of the magnesium ion concentration to the concentration of alkali earth metal cations as equivalent percentage and is called the soluble magnesium percentage (SMgP):

$$SMgP = \frac{[Mg^{2+}]}{[Mg^{2+} + Ca^{2+}]} \cdot 100$$

A harmful effect can be expected if the SMgP value exceeds 50.

c) *Boron hazard*

Under special geological conditions, for instance in California, the natural waters may contain an increased quantity of boron compounds. There is only a narrow gap between concentrations which lead to boron deficiency and those which have a toxic effect on the plant. This is why the boron concentration was introduced as one of the criteria of water suitability for irrigation. Irrigation waters are usually classified on the basis of plant tolerance to boron, as is shown in Table 10.

In determining the suitability of water for irrigation the following properties must be measured:

1. the salt concentration of the water, which can be expressed either in terms of concentration (ppm, g/l) or of electrical conductivity (microsiemens, micromhos);
2. the chemical composition of the water, i.e. a determination of the concentrations of CO_3^{2-}, HCO_3^-, SO_4^{2-}, Cl^-, Ca^{2+}, Na^+, K^+ ions. The sodium hazard (SAR or SSP value), the magnesium hazard (SMgP) and the bicarbonate hazard (RSC or p_{HC}) must be calculated from the concentrations of the ions;
3. the concentrations of toxic compounds must be measured if there is a possibility of their occurrence.

In establishing the limit values for irrigation waters the following factors should be considered:

— the physical and chemical properties of the soils
— the tolerance of the crop to be produced to the toxic effect of salts
— the method of irrigation and the amount of water to be applied.

Among the soil properties it is most important for the following factors to be taken into consideration:

— depth of the water table and the rate of horizontal movement of the groundwater

Table 10

Limits of boron in irrigation waters for crops with different degrees of boron tolerance

Tolerant	Semi-tolerant	Sensitive
4.0 ppm	2.0 ppm	1.0 ppm
Athel (Tamarix aphylla)	Sunflower (native)	Pecan
Asparagus	Potato	Walnut (Black, Persian or English)
Palm (Phoenix canarionsis)	Cotton (Acala and Pima)	
Date palm (P. dactylifera)	Tomato	Jerusalem artichoke
Sugar Beet	Sweetpea	Navy bean
Mangel	Radish	American elm
Garden Beet	Field pea	Plum
Alfalfa	Ragged Robin Rose	Pear
Gladiolus	Olive	Apple
Broadbean	Barley	Grape (Sultanina and Malaga)
Onion	Wheat	Kodota fig
Turnip	Maize	Persimmon
Cabbage	Milo	Cherry
Lettuce	Oat	Peach
Carrot	Zinni	Apricot
	Pumpkin	Thornless blackberry
	Bell pepper	Orange
	Sweet potato	Avocado
	Lima bean	Grapefruit
		Lemon
2.0 ppm	1.0 ppm	0.3 ppm

Table 11

Soil categories according to the water soil properties

Soil categories	Water holding capacity, as volume percentage	Available moisture content as a percentage of the water holding capacity	Permeability in mm/hour
I. Soil with very low water holding capacity and very high permeability	below 16	above 60	above 300
II. Soils with low water holding capacity and very high permeability	16 – 24	50 – 60	above 300
III. Soils with medium water holding capacity and high permeability	24 – 32	50 – 60	100 – 300
IV. Soils with high water holding capacity, a high available moisture content and medium permeability	32 – 40	40 – 50	70 – 100
V. Soils with high water holding capacity, a high available moisture content and medium permeability	32 – 40	20 – 40	70 – 100
VI. Soils with very high water holding capacity and low permeability	above 40	20 – 40	30 – 70
VII. Soils with very high water holding capacity and very low permeability	above 40	below 20	below 30

— genetic type of the soil
— average salt content in the soil layer and the depth of salt accumulation
— calcium-carbonate content in the soil
— the chemistry of soluble salts in the soil and the pH value of the liquid phase of the soil
— ESP and EMgP values of the soils
— water-physical properties of the soil, such as: infiltration rate, moisture content at the field capacity and at the wilting-point of the soils.

The different categories, according to the water-physical properties of the soils, are given in Table 11.

4. Evaluation of natural water sources from the point of view of their applicability for irrigation

It can be decided on the basis of the criteria described above whether a natural water source may be used for irrigation or not.

In determining the limit values of the individual quality criteria, the threefold interaction of soil-water-plant must be taken into account.

Thus, for instance, in those areas where the soil is not salt affected and its soluble salt content is low, in qualifying the irrigation water it must be kept in mind that the non-saline and non-alkaline properties of the soil should not be changed, and the soluble salt content and the amount of exchangeable Na ions should not be increased by irrigation.

If irrigation is to be introduced as a means of amelioration in the case of salt affected soils, or as a means of utilizing soils already ameliorated, the criteria for the quality of the irrigation water must be established so that the composition of the irrigation water applied will contribute to an improvement of the chemical properties of the soil and decrease the salinity or alkalinity.

If salt affected soils are to be utilized without aiming to achieve final and lasting amelioration the mineralization of the irrigation water can be higher than in the case of amelioration.

The limit values of irrigation water quality in Hungary are grouped in Table 12.

Table 12

Quality norms of irrigation waters in Hungary

Suitability	Water type	Total salt, mg/l	Na+, %	Phenolphtalein alkalinity, expressed as soda, mg/l	Soda equivalent
A) Suitable for every soil	1. hydrocarbonate	<500	<35	<10	
	2. hydrocarbonate-sulphate	<500	<40	<10	
	3. hydrocarbonate-chloride-sulphate	<500	<45	<10	
B) Suitable for certain soil types	1. hydrocarbonate	500–650	<35	<10	
	2. hydrocarbonate-sulphate	500–600	<40	<10	
	3. hydrocarbonate-chloride-sulphate	500–650	<45	<10	
	1. hydrocarbonate	650–800	<30	<10	
	2. hydrocarbonate-sulphate	650–800	<40	<10	
	3. hydrocarbonate-chloride-sulphate	650–800	<40	<10	
	1. hydrocarbonate	800–1000	<35	<10	
	2. hydrocarbonate-sulphate	800–1000	<40	<10	
	3. hydrocarbonate-chloride-sulphate	800–1000	<45	<10	
C) Suitable fo certain salt affected soil types if irrigation is not connected with soil amelioration	1. hydrocarbonate	800	35–65	10–50	
	2. hydrocarbonate-sulphate	800	35–75	10–50	
	3. hydrocarbonate-chloride-sulphate	800	40–75	10–50	
	1. hydrocarbonate	1000	<35	<50	
	2. hydrocarbonate-sulphate	1000	<40	<50	
	3. hydrocarbonate-chloride-sulphate	1000	<45	<50	
D) Suitable for every soil after chemical amelioration	1. hydrocarbonate	300	<40	50–100	2.0–3
	2. hydrocarbonate-sulphate	300	<45	50–100	2.0–3
	3. hydrocarbonate-chloride-sulphate	300	<50	50–100	2.0–3
E) Suitable for certain soil types after chemical amelioration	1. hydrocarbonate	300–500	<40	100–200	3–6
	2. hydrocarbonate-sulphate	300–500	<45	100–200	3–6
	3. hydrocarbonate-chloride-sulphate	300–500	<50	100–200	3–6
F) Suitable for every soil if improved by dilution	1. hydrocarbonate	500–1000	<60	10–30	
	2. hydrocarbonate-sulphate	500–1000	<60	10–30	
	3. hydrocarbonate-chloride-sulphate	500–1000	<60	10–30	
G) Suitable for certain soil types if improved by dilution	1. hydrocarbonate	1000–2000	<70	10–50	
	2. hydrocarbonate-sulphate	1000–2000	<70	10–50	
	3. hydrocarbonate-chloride-sulphate	1000–2000	<70	10–50	

According to Table 12 the main groups are as follows:

A) Irrigation water suitable for every soil. In this category the maximum permissible values of concentration, and the relative amounts of Na and Mg ions in the irrigation water and of phenolphtalein alkalinity expressed as soda were determined so that these waters could be used for all types of soil without involving the danger of salinization or alkalization.

B) Irrigation waters suitable for certain types of soil. The limit values of the maximum permissible salt content were established in the light of the drainage conditions and the water regime properties of the soil and of the depth of the water table. Within this category three groups are distinguished:

B/1. Irrigation waters suitable for non-salt affected soils with loamy mechanical composition and with good water regime properties (water regime categories 3 and 4), if the water table is not near the surface. (The chernozem soils of the Hungarian Plain, certain meadow chernozems and alluvial meadow soils, etc.)

B/2. Irrigation waters suitable for non-salt affected soils with sandy-loamy mechanical composition and good water infiltration capacity, if the water table is not near the surface and the drainage conditions are very good. (Certain chernozem soils, alluvial soils, etc.)

B/3. Irrigation waters suitable for non-salt affected sandy soils with high infiltration capacity and water conductivity, if the water table is not near the surface.

C) Irrigation waters suitable for salt affected soils utilized as pastures. The limit values of maximum salt content and ESP established for this category are relatively high. Two groups are distinguished within this category:

C/1. Irrigation waters suitable for salt affected soils with clayey texture if they are not ameliorated and only utilized as irrigated pastures. (Shallow and middle meadow solonetz soils and solonchakized meadow soils with heavy mechanical composition on the Hungarian Plain, etc.)

C/2. Irrigation waters suitable for salt affected soils of high salt content with a sandy subsoil if the area is not ameliorated and only utilized as an irrigated, salt affected pasture.

In the case of the irrigation water sources in Hungary it is unnecessary to establish upper limit values of the quality criteria for the irrigation water. The maximum permissible salt concentration and other limit values of the irrigation water have to be determined according to the local environmental conditions and land use.

I. Szabolcs, K. Darab

Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences, Research Institute for Water Resources, Budapest

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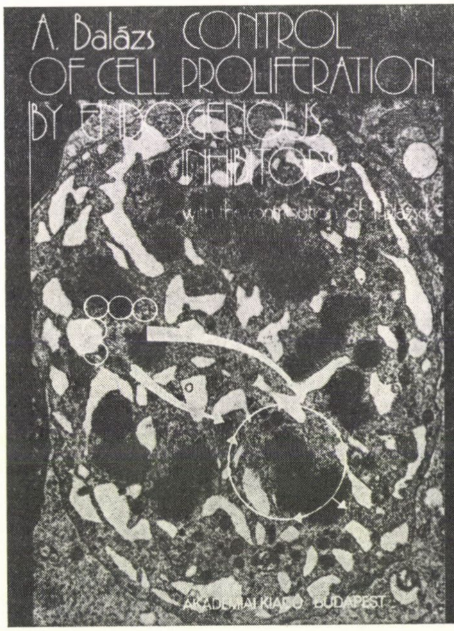
RECENSIONES

A. Balázs (1979): *Control of the cell proliferation by endogenous inhibitors.* Akadémiai Kiadó, Budapest



Very few cell physiological processes have absorbed the attention of researchers as much as cell proliferation has done in recent decades. In spite of this our knowledge of cell proliferation is far from complete. This is partly due to the fact that up-to-date methods for studying the process of cell proliferation have only been available for twenty years or so, and partly to the fact that society expects researchers not only to understand normal cell proliferation but also to find effective means of intervening in the pathological process; in other words, they are expected to find an antidote to tumorous cell proliferation. There can be no doubt that today tumours are some of the most frightening and insidious diseases. Enormous efforts have been and are being made all over the world to gain full knowledge of pathological cell proliferation and learn to control it. Nevertheless, the non-professional, malignant criticism that more people make a living out of cancer than die of it does contain a grain of truth. However, the scientific approach throws light upon the extreme complexity and difficulty of the question. In short: it is not simply cancer that has to be overcome, but a diversity of tumorous diseases which appear in various forms, with different symptoms depending on personal conditions, and which give different responses to X-ray and chemotherapy, so that each tumorous disease demands individual consideration and treatment.

Nowhere in the world is society fully prepared for this task. In the first place there are great deficiencies in basic knowledge, as not even the course of normal cell division is sufficiently clear, not to mention the mechanism of pathological cell proliferation. Yet during the last two decades new branches of science have come into existence; ultrastructural cytomorphology and cytochemistry have disclosed considerable detail of nuclear and chromosomal fine structure. Molecular cytobiology and genetics have made it possible to examine processes on the level of macromolecules. More and more particulars of the process of cell division have become known — and the time will come when the details are synthesized into a complete body of knowledge. And then a new problem will arise: is a single human brain able to take in this vast amount of knowledge and make it practically available?

The question is still waiting to be answered, but until then hundreds of carefully chosen research groups are engaged in collecting and systemizing the accumulated pieces of knowledge and creating possibilities for practical application. One possible solution might be the following: editors with a comprehensive view of the subject would select the prominent representatives of the individual fields of research, so the best and most recent results of research would be available to everybody in a single volume. It cannot be claimed that this will be the only solution adopted in the future — there may be, and already are, those who collect the interdisciplinary research results and try to adapt them to their own narrower or wider fields of research. A. Balázs, the author of the book in question is one of them. His work deserves attention if only because he undertook to study endogenous inhibitors of cell division which were not completely purified chemically, so that their identification, application and the evaluation of their effects encountered numerous difficulties. The author had the courage to rely on his own research results, which form the basis of the book and are amply complemented with up-to-date data and theories from the literature. The eight chapters of the book encompass all the important aspects of the question; everything of importance concerning the normal process of cell division and the possible forms of the controlling mechanisms. The reader is made acquainted with the different phases of cell division and the relationships between them, various endogenous inhibitors affecting the morphogenesis, colony formation, regeneration and carcinogenesis. Detailed information is given on the production, biological determination and in vivo action of the endogenous factors controlling cell division. In Chapter 6 the subcellular and molecular controlling mechanisms of the endogenous inhibitors are discussed. In Chapter 7 plenty of practical aspects are also found; the author describes the role of endogenous inhibitors in carcinogenesis and presents possibilities for clinical application. Finally, in Chapter 8 the chemical structure and physico-chemical properties of endogenous inhibitors are described. On the whole, the book answers the purpose expressed in the title and will certainly be a useful manual for many people. Being a morphologist, the writer of this review feels bound to make certain comments, mainly on the first chapter. The author compares DAD (1.2 : 5.6 dianhydrogalacticol) as an alkylating compound with granuloid crude extracts (GCE) for their effects on thymidine incorporation and on the mitotic index. He then demonstrates by means of 19 electron microscopic pictures the ultrastructural changes induced by the two compounds, in order to support his views on the action of the drug. As a morphologist I do not consider this demonstration to be a wise choice for various reasons. The first reason is a technical one, but is very important. Most of the figures are of poor quality: they are not properly fixed, defocussed, too hard or too grey. The overmagnified pictures do not suit the purpose either; cell details shown are too small to give any indication of what might have happened in the cell as a whole. There is not a single untreated control among the figures, so the supposed changes cannot be compared to anything. The captions say too little, often nothing at all; e.g. the author repeatedly mentions membrane anomalies instead of describing a particular membrane alteration. It is clear, for example, that in Fig. 4a the discontinuity of the nuclear membrane is not a lesion caused by the drug, but the result of the tangential plane of section. Figure 5b is intended to show another membrane anomaly, but it quite clearly shows the development of the quadrilamellar membrane described in numerous tumour cells after treatments with various antitumourous drugs as a sign of structural disorders in the regeneration of the nuclear membrane. Having carefully studied the figures the writer of this review has the impression that the author of the book is not sufficiently well trained in morphology, and his figures thus cause confusion instead of leading to a better understanding of the contents of the book. As regards the merits of the case, the author used a single LD 50 dose of DAD for the ultrastructural analyses. This huge dose is totally unsuitable for inducing specific ultrastructural changes in the cells, so the comparison with GCE is unrealistic. Even the figures which show the erythroid and lymphoid precursors of GCE-treated bone-marrow, in which the author claims an intact cell structure can be observed, are not convincing. In the erythroid cell in Fig. 8a a swelling lesion to the mitochondria is clearly seen in spite of the small scale of enlargement.

These deficiencies give a clear warning to authors and editors to find suitable experts to read through each chapter so that the necessary corrections can be made in good time.

I. Benedeczky

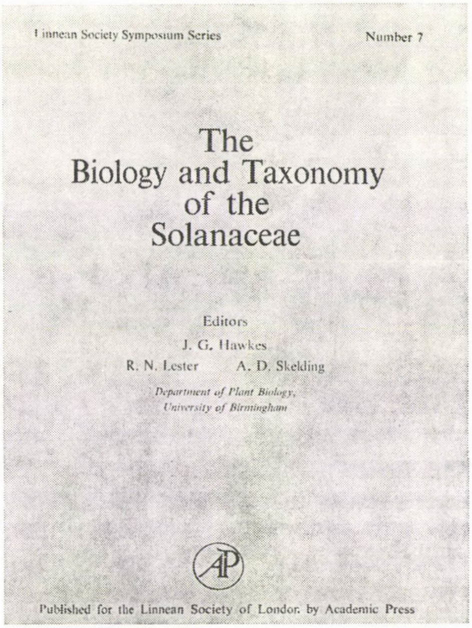
J. G. Hawkes, R. N. Lester, A. D. Skelding: The Biology and Taxonomy of the Solanaceae. Published for the Linnean Society of London by Academic Press, London, 1979, pp. 738.

This work is the 7th volume of the Linnean Society Symposium Series. It contains the lectures held at an international symposium on the biology and taxonomy of the *Solanaceae* family. The symposium was organized by the Plant Biology Section of Birmingham University and was held in Birmingham on 13—17th July 1976.

The Solanaceae family is one of the largest families of flowering plants, including a wide range of economically and therapeutically important species. A great number of authors from various fields of science give internationally unequalled surveys of different aspects of this important plant family.

The material is treated in 9 sections.

Section I discusses the taxonomic and floristic lectures: The classification of the



Solanaceae by D'Arcy; Solanaceae in South America, in India and in Nigeria by Hunziker, Deb and Gbile, respectively; Haegi on the Australian genera of the *Solanaceae*, Symon on the genus *Solanum* in Australia, and Hepper on typifying Linnaean names of *Solanaceae*.

The subject of Section II is ethnobotany. Schultes writes about the solanaceous hallucinogens and their role in the development of New World cultures, Mehra about the ethnobotany of Old World *Solanaceae*, and Peterson deals with the aboriginal uses of Australian *Solanaceae*.

Sections III and IV discuss the analysis and chemical components of *Solanaceae*. Schreiber gives information on the steroid alkaloids of *Solanum*, Bradley—Collins—Eastwood—Irvine—Swan—Symon on the distribution of steroid alkaloids in Australian species of *Solanum*, Máthé Jr.—Máthé Sr. write about the variation of alkaloids in *Solanum dulcamara* L., Roddick deals with the distribution of steroidal glycoalkaloids in cells of *Solanum* and *Lycopersicon*, Miller—Davies study the characteristics of solasodine accumulation in *Solanum khasianum* var. *chatterjeanum* and *S. laciniatum* grown under field conditions in Birmingham, Ford—McCance—Drysdale give an account of the hydrolysis of tomatine by an inducible extracellular enzyme from *Fusarium oxysporum* f. sp. *lycopersici*, while Evans describes the tropane alkaloids of the *Solanaceae*.

Harborne—Swain discuss the flavonoids of the *Solanaceae*, Parmentier the biosynthesis of chlorogenic acid in *Solanaceae*, and Reid the diterpenes of *Nicotiana* species and *N. tabacum* cultivars; Stegemann presents a characterization of proteins from potatoes and an index of European varieties, while Lester makes the readers acquainted with the use of protein characters in the taxonomy of *Solanum* and other *Solanaceae*.

In Sections V and VI new aspects of the anatomy, ultrastructure, morphology and morphogenesis of the *Solanaceae* are considered. Chapters included in these sections are: Seithe: Hair types as taxonomic characters in *Solanum;* Bessis—Guyot: An attempt to use stomatal characters in systematic and phylogenetic studies of the *Solanaceae;* Gentry: Pollen morphology of the *Salpiglossideae (Solanaceae);* Gbile—Sowunmi: The pollen morphology of Nigerian *Solanum* species; Child: A review of branching patterns in the *Solanaceae;* Hammond: Growth regulator interactions on morphogenesis in *Solanum* species; Coutts: Observations on the isolation, morphology and culture of potato leaf and meristem protoplasts; Westcott—Grout—Henshaw: Rapid clonal propagation of *Solanum curtilobum* cv. *Mallku* by aseptic shoot meristem culture.

Section VII discusses flower biology; these chapters are of special importance for plant breeders as they deal with cultivated plants. Such studies include: Symon: Sex forms in *Solanum (Solanaceae)* and the role of pollen collecting insects; Quagliotti: Floral biology of *Capsicum* and *Solanum melongena;* Pandey: The genus *Nicotiana:* evolution of incompatibility in flowering plants; Hogenboom: Incompatibility and incongruity in *Lycopersicon;* Hermsen—Sawicka: Incompatibility and incongruity in tuber-bearing *Solanum* species; Pochard—Dumas de Vaulx: Haploid parthenogenesis in *Capsicum annuum* L.

Sections VIII and IX contain biosystematic studies of genera, sections and cultivated species. These chapters attempt to show how the previous chapters can be put to practical use. The authors deal with the following subjects. Plowman: The genus *Brunfelsia:* a conspectus of the taxonomy and biogeography; Averett: Biosystematics of the physaloid genera of the *Solanaceae* in North America; Jackson—Berry: *Mandragora* taxonomy and chemistry of the European species; Heiser—Burton—Schilling: Biosystematic and taxometric studies of the *Solanum nigrum* complex in eastern North America; Edmonds: Biosystematics of *Solanum* L. section *Solanum (Maurella);* Anderson: Systematic and evolutionary consideration of species of *Solanum* section *Basarthrum;* Roe: Dispersal and speciation in *Solanum*, section *Brevantherum;* Nee: Patterns in biogeography in *Solanum*, section *Acanthophora;* Whalen: Speciation in *Solanum*, section *Androceras;* Omidiji: Crossability relationships between some species of *Solanum*, *Lycopersicon* and *Capsicum* cultivated in Nigeria; Rao: The barriers to hybridization between *Solanum melongena* and some other species of *Solanum;* Pearce—Lester: Chemotaxonomy of the cultivated eggplant — a new look at the taxonomic relationships of *Solanum melongena* L.; Khan: *Solanum melongena* and its ancestral forms; Hawkes: Evolution and polyploidy in potato species; Ramanna—Hermsen: Genome relationships in tuber-bearing *Solanums*; Grun: Evolution of the cultivated potato: a cytoplasmic analysis; Rick: Biosystematic studies in *Lycopersicon* and closely related species of *Solanum;* Pickersgill—Heiser—Neill: Numerical taxonomic studies on variation and domestication in some species of *Capsicum;* McLeod—Eshbaugh—Guttman: A preliminary biochemical systematic study of the genus *Capsicum-Solanaceae.*

There is then a brief chapter presenting the resolutions adopted at the symposium, and finally a taxonomic index and a general index.

The book is of extreme importance for all those who deal with any aspect of plants belonging to the Solanaceae family. Plant growers, agricultural researchers, botanists, pharmacologists, biochemists, etc. can acquaint themselves with the most recent data and acquire up-to-date knowledge from the world-wide review offered by this book.

I. MÁTHÉ

INDEX

VARIA

FORUM

CHRONICA

AS I SEE IT . . .

LECTIONES

RECENSIONES

INDEX

EUPHYTICA

NETHERLANDS JOURNAL OF PLANT BREEDING,

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The Netherlands

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ACTA AGRONOMICA

TOMUS XXXI

INDEX

Fasc. 1—2

LECTIONES

RECENSIONES

INDEX

Fasc. 3—4

VARIA

FORUM

CHRONICA

AS I SEE IT . . .

LECTIONES

RECENSIONES

INDEX

Acta Agronomica Academiae Scientiarum Hungaricae, Tomus 31 (3—4), pp. 201—206 (1982)

TRENDS OF ABOVE-EAR AND BELOW-EAR LEAF AREAS AND OF GRAIN YIELD PER UNIT LEAF AREA IN MAIZE (ZEA MAYS L.) HYBRIDS WITH DIFFERENT GENOTYPES

By

L. PINTÉR

CEREAL RESEARCH INSTITUTE, SZEGED

Leaf area, and grain yield per 100 cm^2 leaf area in 8 maize hybrids with different genotypes and vegetation periods, commercially produced in Hungary, were studied in a two-year field experiment. On the basis of the investigations it can be established that the area of leaves above the main ear is in close correlation with the total leaf area of the plant. There are significant differences between the hybrids in the grain yield per 100 cm^2 leaf area. The surplus of grain yield per unit area of leaves above the main ear compared to grain yield per unit leaf area of the whole plant varies with the genotype, which suggests that the hybrids give different responses to artificially induced stresses.

Introduction

The principal task of the grain maize breeders is to produce maize hybrids with small vegetative masses and large grain yields. A positive correlation between leaf area and grain yield was reported by BAJAI (1959), NUNEZ—KAMPRATH (1969), NÖSBERGER (1971) and RUMAWAS *et al.* (1971). HEICHEL—MUSGRAVE (1969), AKIYAMA—TAKEDA (1975) and BONCIARELLI—MONOTTI (1975) found considerable differences between hybrids and inbred lines with various genotypes in the productivity of the leaf area. NÉMETH—PINTÉR (1975) and PINTÉR *et al.* (1977) pointed out differences in the productivity of leaves at different heights.

The relationship between the areas of leaves at different heights (6th and 8th leaf) and the leaf area of the whole plant was studied by JOHNSON (1974), PEARCE *et al.* (1975) and FAKOREDE *et al.* (1977). These authors consider that the generative or vegetative character of a plant is well characterized by the areas of leaves at different heights.

In the course of the current investigations answers to the following questions were sought: what relation is there between the area of above-ear leaves and the total leaf area in hybrids with different genotypes? Is the grain yield per unit area of leaves at the same height identical in hybrids with different genotypes, and if not, is the difference characteristic of the genotypes?

Material and method

The experimental material consisted of hybrids with different genotypes and vegetation periods bred and maintained by the Cereal Research Institute, Szeged and commercially produced in Hungary. The genotypes of the hybrids, according to the serial numbers used in Table 1, were: 1. (GK71 × GK72)-153R, 2. (GK1 × GK3)—(GK2 × W37A), 3. A90 × 153R, 4. Szv293 × 153R, 5. (GK73 × C22)—(W64A × WF9), 6. A632 × 153R-base, 7. (A632 × GK17)-GK13, 8. Oh43/K × A632. The vegetation period is shown by the FAO number (the three-figure number in the name of the hybrid).

The experiment was carried out in 1976 and 1977 at the "Ságvári" station of the research institute in Szeged (at latitude 46°N in the temperate zone). At silking the leaf area was reduced to a varying extent, whereby the following treatments were obtained: 1. control, all leaves left, 2. only leaves above the main ear left, 3. only half the leaves above the main ear left. The treatments included 15 plants per plot without replication in 1976, and 12 plants per plot with 3 replications, a total of 36 plants in a random block design, in 1977.

The seeds were sown in both years to a stand density of 6 plants/m² in rows spaced at 70 cm. The development of the plants was not disturbed by soil, nutrient, precipitation, heat or light conditions in either of the years.

When the leaves were removed at silking the lengths and maximum widths of the leaves were measured in all three treatments, after which the leaf area per plant was calculated using Montgomery's formula. The results were in agreement with those of ALLISON (1964), who stated that after flowering the leaf area no longer grew.

In all the treatments on each hybrid the plants were harvested individually at 30% grain moisture, and were processed, again individually, at 14% (air-dried) grain moisture content. The productivity of the leaf area was characterized by the air-dried grain yield per 100 cm² leaf area. The investigation was disturbed to some extent by the assimilating stalk and leaf sheath. However, the aim of the experiment was to demonstrate differences between the hybrids, so this error can be ignored. The yield-reducing effect of injuries caused by the removal of the leaves can be treated similarly.

Evaluation was again carried out for each plant separately. When evaluating each parameter a correlation coefficient (r) for the data of the two years was calculated and the significance was determined. If the correlation coefficient did not give a significant correlation between the data of the two years even at $P_{5\%}$, the data series was excluded from the evaluation.

Results

The leaf area data (Table 1) show significant differences between hybrids with different genotypes in all three treatments. Taking the significant difference at $P_{5\%}$ as the basis, the two-year data for the three treatments lead to the conclusion that the leaf area increases with the length of the vegetation period. The only exception is the hybrid Sze SC 369, which proves that the leaf area can be increased by breeding irrespective of the length of the vegetation period.

Figure 1 shows the correlation between the total leaf area of the plant, the above-ear leaf area, and the area of half the leaves above the ear. The correlation coefficients reveal a significant close correlation in both cases at $P_{0.1\%}$. The partial data fit in well with a straight-line curve, so on the average of 8 hybrids the area of the leaves above the ear is considered to characterize the total leaf area of the plant.

The grain yield per unit (100 cm²) leaf area is shown in Table 2. The following coefficients were obtained for the correlations between the data of

Table 1

Trend of leaf area (cm^2) per plant by treatment and hybrid

Serial number	Hybrid	Total leaves		Only leaves above the main ear left		Only half the leaves above the main ear left	
		1976	1977	1976	1977	1976	1977
1.	Sze TC 255	4631.7	4414.1	2058.0	2186.8	924.5	1076.5
2.	Sze DC 289	4562.2	5013.8	2028.2	2039.2	1045.3	1164.5
3.	K SC 360	5739.3	5691.9	2463.1	2714.3	1547.4	1628.3
4.	Sze SC 369	6276.0	6632.6	2728.3	3388.0	1612.0	2024.5
5.	Sze DC 384	5584.0	6298.0	2413.2	2714.0	1147.5	1395.9
6.	Bc 418	6026.9	6268.3	2746.1	2729.2	1538.4	1676.4
7.	Sze MSC 515	6815.0	6750.6	2824.1	2838.3	1778.3	1713.8
8.	Sze SC 565	6820.1	7497.2	3372.9	3546.9	2110.8	2153.4
$LSD_{5\%}$		390.10	301.13	260.60	179.64	189.10	162.20
$LSD_{1\%}$		518.10	395.91	346.20	236.18	251.20	213.25

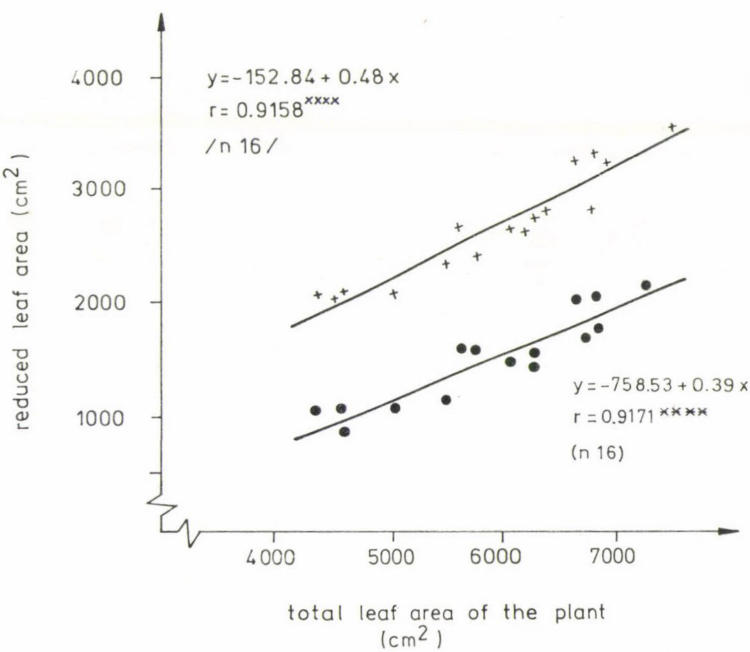

Fig. 1. Correlation between the total leaf area of the plant and the area of leaves above the main ear (Note: + = area of leaves above the main ear; • = area of half the leaves above the main ear)

Table 2

Air-dried grain yield per unit leaf area
(g/100 cm²)

Serial number	Hybrid	Total leaves		Only leaves above the main ear left		Surplus grain yield per 100 cm² leaf area as a percentage of that for the total leaf area	
		1976	1977	1976	1977	1976	1977
1.	Sze TC 255	3.64	3.53	6.18***	6.37***	69.8	80.5
2.	Sze DC 289	3.69	3.13	4.84***	4.82***	31.2	54.0
3.	K SC 360	3.14	2.92	4.80***	4.90***	52.9	67.8
4.	Sze SC 369	2.90	2.67	5.46***	4.82***	88.3	80.5
5.	Sze DC 384	2.83	2.59	3.83	4.20***	35.3	62.2
6.	Bc 418	2.96	2.70	5.48***	4.88***	85.1	80.7
7.	Sze MSC 515	3.71	3.08	5.27***	4.80***	42.0	55.8
8.	Sze SC 565	3.34	2.74	4.73***	—	41.6	—
$LSD_{5\%}$		0.27	0.19	0.45	0.34		
$LSD_{1\%}$		0.35	0.25	0.60	0.44		

*** The air-dried grain yield per 100 cm² of the leaves above the main ear was significantly larger than when related to the total leaf area $P_{0.1\%}$

the two years: $r = 0.8323$** for the total leaf area, $r = 0.8330$** for the area of the leaves above the main ear, and $r = 0.5390$ for the area of half the leaves above the main ear. The latter is not significant, probably because of the difference between the two years in the number of replications (21 plants). However, this can only be proved by further investigations. This treatment was omitted both from Table 2 and from the further evaluation.

The grain yield per 100 cm² leaf area showed a considerable variation in both treatments. This agrees with the results of Heichel—Musgrave (1969), Akiyama—Takeda (1975) and Bonciarelli—Monotti (1975), and proves that in maize hybrids with different genotypes the grain yield per plant depends not only on the total leaf area but also on the grain yield per unit leaf area. This correlation opens up the possibility of increasing the yield by breeding.

The data of Table 2 unequivocally prove that the grain yield of the above-ear leaf area is larger than that of the below-ear leaf area.

* = $P_{5\%}$, ** = $P_{2\%}$, *** = $P_{1\%}$, **** = $P_{0.1\%}$.

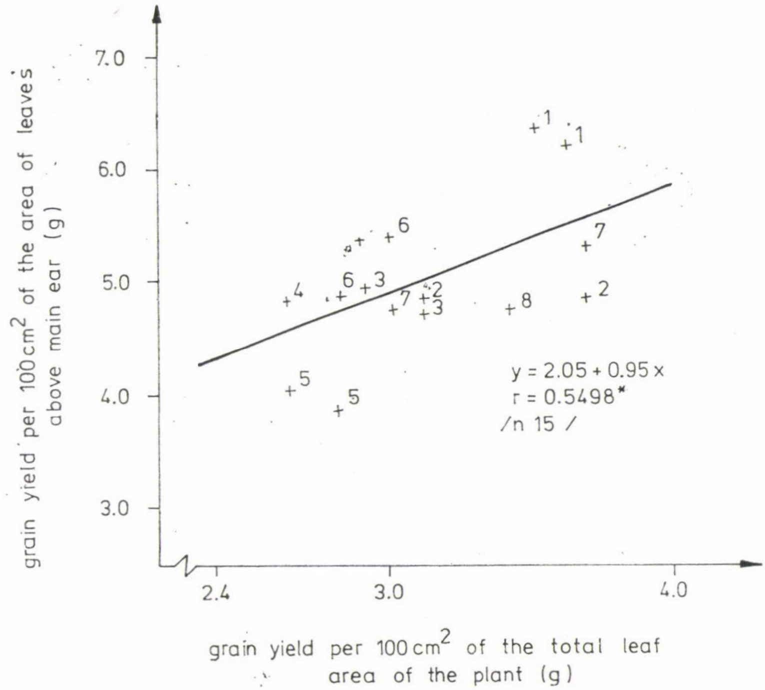

Fig. 2. Correlation between air-dried grain yield per 100 cm² of the total leaf area, and of the area of leaves above the main ear (Note: figures beside the individual data indicate the hybrids, which can be identified on the basis of the serial numbers in the Tables)

The correlation between the grain yield per 100 cm² of the total leaf area and the grain yield per 100 cm² of the leaves above the main ear was examined, as shown in Fig. 2. The correlation coefficient (significant at $P_{5\%}$) indicates a loose correlation, as confirmed by the considerable deviations of the individual data from the straight-line curve. However, the figure indicates that the tendency of the deviation from the general correlation is characteristic of the hybrid, with the exception of K SC 360, hybrid No. 3.

The surplus grain yield per 100 cm² area of the leaves above the main ear was determined as a percentage of the value for the total leaf area in each hybrid. The results are presented in Table 2. On the basis of the numerical data it is clear that the yield surplus per unit area of the leaves above the main ear varies with the genotype of the hybrid. This suggests that there are differences between the hybrids in the degree of tolerance to stresses (removal of the leaves below the ear). The coefficient of correlation between the percentage yield surpluses of the two years is $r = 0.9403^{****}$, which proves that this property of the hybrids can readily be reproduced.

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Acta Agronomica Academiae Scientiarum Hungaricae, Tomus 31 (3—4), pp. 207—385 (1982)

VARIA

SHORT HISTORY OF THE SERIES "THE CULTIVATED PLANTS OF HUNGARY"

In 1955 the Agricultural Section of the Hungarian Academy of Sciences included in its programme the edition of a publication series discussing in detail botanical questions concerning the plants cultivated in Hungary (some 180 species). The main reason given for this plan was that while the natural flora of Hungary had been analysed and published both in scientific works and in a popular form, no comprehensive but detailed description was available of the cultivated plants which formed the basis of Hungarian agriculture. Plant growers and breeders could not dwell on botanical aspects in their handbooks, but nevertheless a thorough knowledge of the taxonomy, morphology, physiological and ecological conditions of the cultivated plants was becoming increasingly necessary in order to solve the problems arising in practice. The few works available on this subject in foreign languages are difficult to acquire and do not discuss specific Hungarian conditions. The publication series was started with the intention of bridging this gap.

The Agricultural Section of the Hungarian Academy of Sciences entrusted the organization of the botanical aspects to Sándor Jávorka and the agricultural sciences to Ferenc Erdei. Further members of the Editorial Board were: Vilmos Frenyó, Andor Jánossy, János Lelley, Imre Máthé, Sándor Sárkány, András Somos, Rezső Soó, János Surányi, István Tamássy and Bálint Zólyomi. The Editorial Board assigned the compilation of the series to Imre Máthé (1959) and the technical editing to Szaniszló Priszter. Irma Allodiatorisz also took part in the work of editing and administration.

The series "The cultivated plants of Hungary" encompasses all the plants cultivated or cultivable in Hungary which can be considered as "agricultural plants" in the broader sense of the word. It thus discusses agricultural crops and vegetable species grown in the field, fruit-bearing plants, phanerogamous and cryptogamous plants for industrial use and cultivated medicinal plants, while it does not discuss ornamental plants or dendrological and forestry species.

The detailed treatment includes the taxonomy, nomination, origin and distribution of the plant concerned, its external and internal morphology, physiological and ecological requirements and development, growth and reproduction conditions, and also touches upon certain breeding and agrotechnical questions. Each treatment gives an extremely detailed list of the relevant literature, and the text is abundantly illustrated with photos and drawings, the latter prepared for the press by Mrs. A. Muhoray on the basis of the authors' original drawings.

To show how the body of knowledge on each plant was to be processed, "sample booklets" for six plants: maize *(Zea mays)*, rough cocksfoot *(Dactylis glomerata)*, saintfoin (*Onobrychis* sp.), walnut *(Juglans regia)*, paprika *(Capsicum annuum)* and flax *(Linum usitatissimum)*, were published. Only after these had been evaluated and discussed were the final form, the arrangement of the contents and the required scientific level established in 1959;

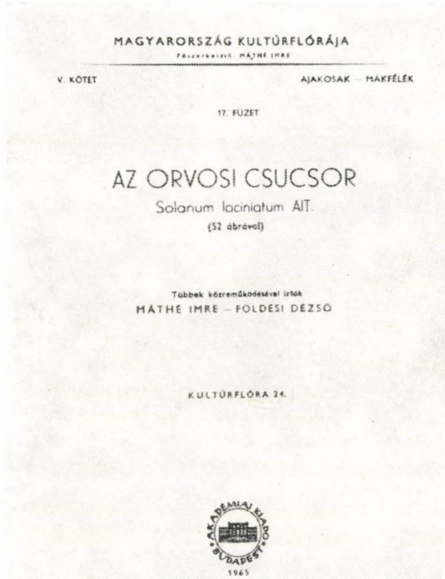

MAGYARORSZÁG KULTÚRFLÓRÁJA
Főszerkesztő MÁTHÉ IMRE
V. KÖTET
AJAKOSAK – MÁKFÉLÉK
17. FÜZET
AZ ORVOSI CSUCSOR
Solanum laciniatum AIT.
(52 ábrával)
Többek közreműködésével írták
MÁTHÉ IMRE – FÖLDESI DEZSŐ
KULTÚRFLÓRA 24.
AKADÉMIAI KIADÓ BUDAPEST
1965

Fig. 1. Title page of *Solanum laciniatum* Ait.

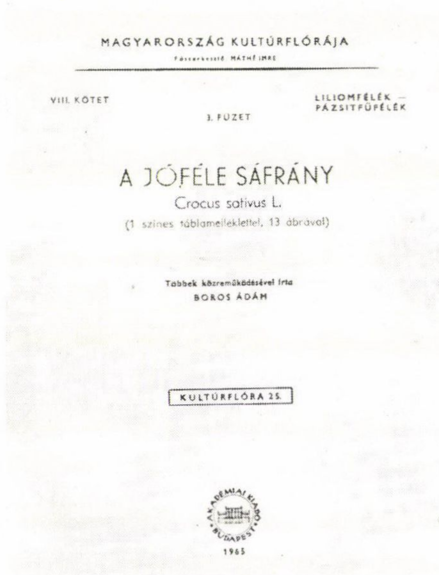
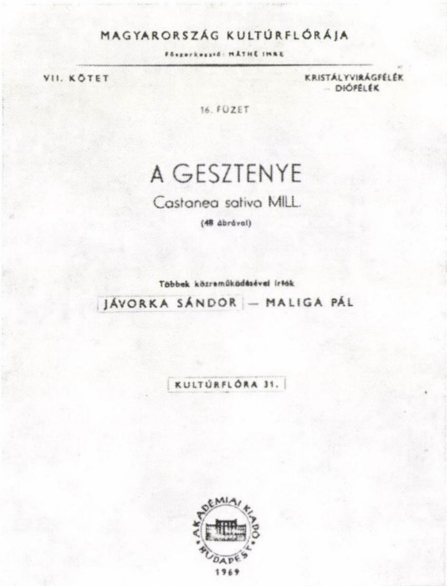

MAGYARORSZÁG KULTÚRFLÓRÁJA
Főszerkesztő MÁTHÉ IMRE
VIII. KÖTET
LILIOMFÉLÉK – PÁZSITFŰFÉLÉK
3. FÜZET
A JÓFÉLE SÁFRÁNY
Crocus sativus L.
(1 színes táblamelléklettel, 13 ábrával)
Többek közreműködésével írta
BOROS ÁDÁM
KULTÚRFLÓRA 25.
AKADÉMIAI KIADÓ BUDAPEST
1965

Fig. 2. Title page of saffron crocus (*Crocus sativus* L.)


MAGYARORSZÁG KULTÚRFLÓRÁJA
Főszerkesztő: MÁTHÉ IMRE

VII. KÖTET

KRISTÁLYVIRÁGFÉLÉK – DIÓFÉLÉK

16. FÜZET

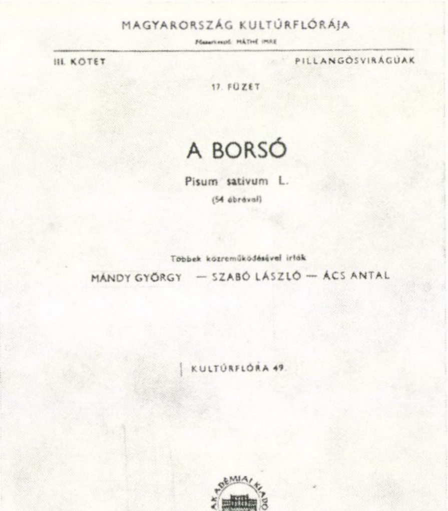
A GESZTENYE
Castanea sativa MILL.
(48 ábrával)

Többek közreműködésével írták
JÁVORKA SÁNDOR – MALIGA PÁL

KULTÚRFLÓRA 31.

AKADÉMIAI KIADÓ BUDAPEST
1969

Fig. 3. Title page of chestnut (*Castanea sativa* Mile)


MAGYARORSZÁG KULTÚRFLÓRÁJA
Főszerkesztő: MÁTHÉ IMRE

III. KÖTET

PILLANGÓSVIRÁGÚAK

17. FÜZET

A BORSÓ
Pisum sativum L.
(54 ábrával)

Többek közreműködésével írták
MÁNDY GYÖRGY – SZABÓ LÁSZLÓ – ÁCS ANTAL

KULTÚRFLÓRA 49

AKADÉMIAI KIADÓ BUDAPEST
1980

Fig. 4. Title page of pea (*Pisum sativum* L.)

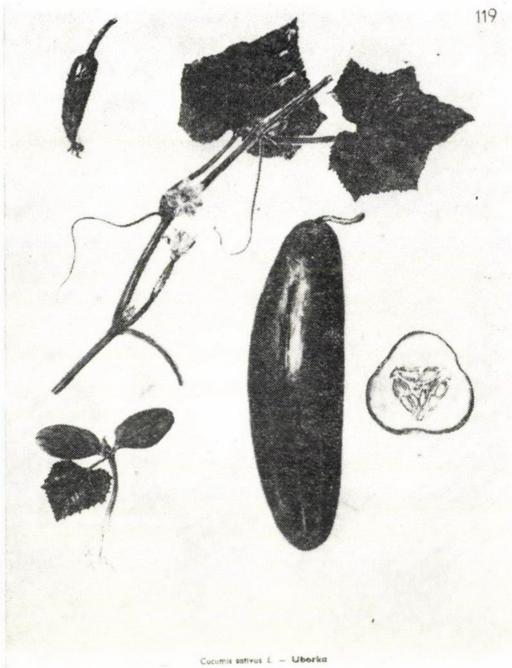


Fig. 5. Plate of cucumber (*Cucumis sativus* L.)

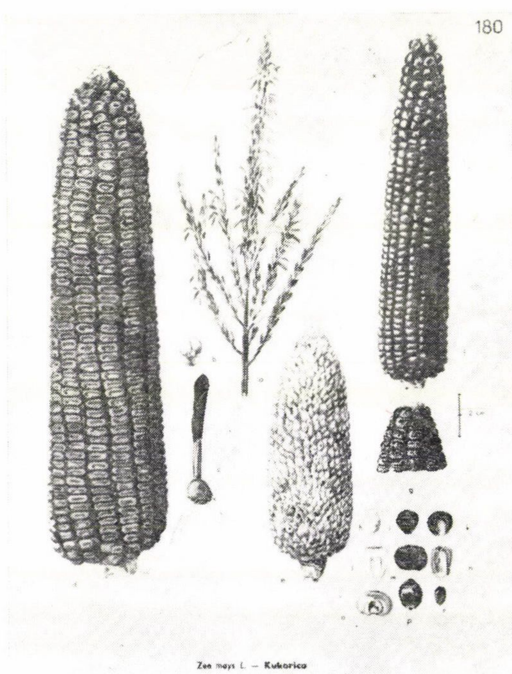


Fig. 6. Plate of maize (*Zea mays* L.)

the volumes or booklets of the series have since been published according to uniform principles as regards content and editing.

At present the general editor is Imre Máthé, while the other members of the editorial board are: Béla Dános, László Heszky, István Kárpáti, Albert Koltay, Szaniszló Priszter Sándor Sárkány, András Somos, László Szabó, Júlia Szujkó-Lacza, András Terpó, Gizella Verzár-Petri and Bálint Zólyomi. The work of compilation is carried out by Imre Máthé and Szaniszló Priszter.

Each monograph is the result of teamwork in which usually 6—8, but sometimes as many as 15—17 authors take part. Although only 1 or 2 names are generally found on the title page of the booklet, the list of contents shows the names of all the authors. This collective work has great advantages, because it ensures a high professional standard for all aspects; the only disadvantage is that it takes more time and effort to prepare the manuscript for the press.

In the past twenty years 50 books or booklets have been published, with a total of over 5400 pages and 2150 figures. The 50 indexes contain more than 50,000 names on nearly 500 pages; in the lists of references (some 350 pages) about 12,000 titles are to be found, Volume I of the planned ten-volume work discusses the bacteria, algae and fungi, i.e. the cryptogamous microorganisms used industrially. After a general microbiological introduction. booklets on Acetibacteria, Lactobacteria, Butyl alcohol bacteria, Nitrogen-fixing bacteria, Antibiotic-producing ray fungi, Yeast fungi, Mould fungi, Ergot, Champignon and Cultivated algae have appeared, with 2 appendices and indexes, on a total of approximately 1500 pages (volumes IA and IB).

The series discussing the phanerogamous plants was begun with volume X, which contains coloured pictures of the cultivated plants (1961). The Coloured Atlas presents 180 plates (of size B/4) containing characteristic pictures and certain details (on some 1300 detailed drawings) of the cultivated plants specified in vols I—IX of the series. The pictures in the Atlas are works of art painted by Vera Csapody under the guidance of Sándor Jávorka. The original water colours, which are life-sized as far as possible, were all painted from living plants. 24×34 cm plates were then prepared from the pictures with a multicolour offset technique; besides the habitus they sometimes show the different developmental stages (e.g. seedling, bud, etc.) and characteristic organs (e.g. root, part of stem, inflorescence, flower, fruit, seed, etc.) of the plants illustrated. The collection of figures was supplemented with an explanatory booklet giving brief information about the most important properties of the plants. This coloured map was published in 1976 in Polish too.

Monographs on phanerogamous plants belonging to taxonomically different volumes (II—IX) are published in the order in which they are prepared for the press, and are combined into taxonomically correct volumes later.

A list of the plants processed so far is given below, with the serial numbers indicated.

15. hemp	*Cannabis sativa*
16. garden orache	*Atriplex hortensis*
17. corn spurrey	*Spergula arvensis*
18. fig	*Ficus carica*
19. wheat	*Triticum aestivum*
20. tall oatgrass	*Arrhenatherum elatius*
21. beet and related species	*Beta vulgaris*
22. chervil	*Anthriscus cerefolium*
23. potato	*Solanum tuberosum*
24. medicinal nightshade	*Solanum laciniatum*
25. saffron	*Crocus sativus*

26. grapevine	*Vitis vinifera*
27. hop	*Humulus lupulus*
28. chickling-vetch	*Lathyrus sativus*
29. lavender	*Lavandula officinalis*
30. meadow foxtail	*Alopecurus pratensis*
31. chestnut	*Castanea sativa*
32. dill	*Anethum graveolens*
33. lentil	*Lens culinaris*
34. spinach	*Spinacia oleracea*
35. timothy	*Phleum pratense*
36. mulberry tree	*Morus alba*
37. groundnut	*Arachis hypogaea*
38. mullein	*Verbascum phlomoides*
39. fenugreek	*Trigonella foenum-graecum*
40. honeybee plant	*Phacelia tanacetifolia*
41. bird's foot trefoil	*Lotus corniculatus*
42. aniseed	*Pimpinella anisum*
43. tomato	*Lycopersicum esculentum*
44. New Zealand spinach	*Tetragonia tetragonoides*
45. camomile	*Matricaria chamomilla*
46. melilot	*Melilotus* sp.
47. buckwheat	*Fagopyrum esculentum, F. tataricum*
48. rye-grass and related species	*Lolium perenne*
49. pea	*Pisum sativum*

The texts are compiled by a large team of nearly 300 botanists and agriculturists. Such a large team is not involved in editing similar series either in Hungary or abroad. The manner in which the cultivated plants are treated greatly enhances the importance and usefulness of the work; researchers, teachers and all those engaged theoretically or practically in any branch of agriculture are given the most up-to-date scientific survey of cultivated plants, with a wide range of literary references. From the 46th booklet (1980) onwards, English and Russian lists of contents are included in order to attract the interest of foreigners to the series.

Further cultivated plants which are planned for inclusion in the series are grouped below by family.

Rosaceae

quince *(Cydonia oblonga)*, pear *(Pyrus domestica)*, apple *(Malus sylvestris* var. *domestica)*, sorb *(Sorbus domestica)*, medlar *(Mespilus germanica)*, raspberry *(Rubus idaeus)*, blackberry *(Rubus procerus)*, strawberry *(Fragaria ananassa)*, apricot *(Prunus armeniaca)*, almond *(Prunus amygdalus)*, peach *(Prunus persica)*, plum, greengage *(Prunus domestica)*, cherry *(Prunus avium)*, sour cherry *(Prunus cerasus)*.

Saxifragaceae

gooseberry *(Ribes uva-crispa)*, currant (*Ribes* sp.)

Papilionaceae

lupin (*Lupinus* sp.), lucerne (*Medicago* sp.), clover (*Trifolium* sp.), kidney vetch *(Anthyllis vulneraria)*, sweet-root *(Glycirrhiza glabra)*, serradella *(Ornithopus sativus)*, saintfoin (*Onobrychis* sp.), chickling pea *(Cicer arietinum)*, horse-bean *(Vicia faba)*, vetches (*Vicia* sp.), soya *(Glycine soja)*, cowpea *(Vigna sinensis)*, beans (*Phaseolus* sp.).

Cornaceae

cornel *(Cornus mas)*

Umbelliferae

coriander *(Coriandrum sativum)*, celery *(Apium graveolens)*, parsley *(Petroselinum crispum)*, caraway *(Carum carvi)*, fennel (*Foeniculum* sp.), lovage *(Leisticum officinale)*, parsnip *(Pastinaca sativa)*, carrot *(Daucus carota)*.

Valerianaceae

valerian *(Valeriana officinalis)*, lamb's lettuce *(Valerianella locusta)*.

Malvaceae

black hollyhock *(Althaea rosea* var. *nigra)*, cotton *(Gossypium hirsutum)*.

Linaceae

flax *(Linum usitatissimum)*.

Euphorbiaceae

castor oil plant *(Ricinus communis)*

Asclepiadaceae

milkweed *(Asclepias syriaca)*.

Boraginaceae

comfre *(Symphytum* × *uplandicum)*.

Labiatae

rosemary *(Rosmarinus officinalis)*, garden sage *(Salvia officinalis)*, muscat sage *(Salvia sclarea)*, lemon-balm *(Melissa officinalis)*, savory *(Satureia hortensis)*, hyssop *(Hyssopus officinalis)*, marjoram *(Majorana hortensis)*, thyme *(Thymus vulgaris)*, mint (*Mentha* sp.), basil *(Ocimum basilicum)*.

Solanaceae

belladonna *(Atropa bella-donna)*, henbane *(Hyoscyamus niger)*, paprika *(Capsicum annuum)*, eggplant *(Solanum melongena)*, black nightshade *(Solanum dulcamara)*, thorn apple (*Datura* sp.), tobacco (*Nicotiana* sp.).

Scrophulariaceae

foxglove (*Digitalis* sp.).

Papaveraceae

poppy *(Papaver somniferum)*.

Cruciferae

black mustard *(Brassica nigra)*, turnip *(Brassica rapa)*, cabbage *(Brassica oleracea)*, rape *(Brassica napus)*, white mustard *(Sinapis alba)*, radish *(Raphanus sativus)*, horse radish *(Armoracia rusticana)*, gold-of-pleasure *(Camelina sativa)*, golden cress *(Lepidium sativum)*.

Cucurbitaceae

gourd *(Lagenaria siceraria)* vegetable marrow (*Cucurbita* sp.), watermelon *(Citrullus lanatus* var. *caffer)*, sweet melon *(Cucumis melo)*, cucumber *(Cucumis sativus)*.

Compositae

sunflower *(Helianthus annuus)*, Jerusalem artichoke *(Helianthus tuberosus)*, safflower *(Carthamus tinctorius)*, blessed thistle *(Cnicus benedictus)*, endive *(Cichorium endivia)*, chicory *(Cichorium intybus)*, black salsify *(Scorzonera hispanica)*, lettuce *(Lactuca sativa)*, Roman camomile *(Anthemis nobilis)*, pellitory *(Chrysanthemum cinerariae-folium)*, tarragon *(Artemisia dranunculus)*.

Portulacaceae

purslain *(Portulaca oleracea* var. *sativa)*.

Chenopodiaceae

wormseed *(Chenopodium ambrosioides)*.

Polygonaceae

garden sorrel (*Rumex sp.*), rhubarb *(Rheum rhabarbarum)*.

Betulaceae

hazel (*Corylus* sp.).

Juglandaceae

walnut *(Juglans regia)*.

Liliaceae

onion (*Allium* sp.), asparagus *(Asparagus officinalis)*.

Gramineae

brome *(Bromus)*, fescue (*Festuca* sp.), sodic grass *(Puccinellia distans)*, meadow grass (*Poa* sp.), rough cocksfoot (*Dactylis* sp.), dog's-tail *(Cynosurus cristatu)*, wheat-grass (*Agropyron* sp.), rye *(Secale cereale)*, barley *(Hordeum vulgare)*, Bermuda grass*(Cynodon dactylon),m* caterpillar grass *(Beckmannia eruciformis)*, oat grass *(Trisetum flavescens)*, oat *(Avena sativa)*, agrostis *(Agrostis alba)*, vernal grass *(Anthoxanthum odoratum)*, canary grass *(Phalaris canariense)*, rice *(Oryza sativa)*, millet *(Panicum miliaceum)*, foxtail millet *(Setaria italica)*, broomcorn *(Sorgum dochna)*, Sudan grass *(Sorgum sudanense)*, maize *(Zea mays/*, reed grass *(Typhoides arundinacea)*.

As shown by the above review, the series "Magyarország Kultúrflórája" (The cultivated plants of Hungary) is a much-needed work, internationally unparallelled of its kind, since the large number of authors involved makes it possible to give a very full picture of the present knowledge on the cultivated plants discussed. Although the series is published in Hungarian, the broad conception will also be appreciated by specialists abroad; this is the purpose of the English and Russian lists of contents added to the series recently (1980), and is also the aim of this review.

I. Máthé

WHEAT BULB FLY (LEPTOHYLEMYIA COARCTATA FALL.)

Distribution. The wheat bulb fly (*Leptohylemyia coarctata* Fall. Syn.: *Delia coarctata* Fall., *Phorbia coarctata* Fall.) is a pest which has long been known in the cereal growing countries of Europe. In England it is very frequent (BARDNER—KENTEN 1957, BARDNER 1958, 1959, 1968, GEMMILL 1927, GOUGH 1946, 1947, 1950, GOUGH *et al.* 1961, LONG 1957, 1959a, 1959b, 1960, RAW 1954, 1960, 1967, WAY 1959). According to FABER (1968) the wheat bulb fly occurs in Austria as well. Investigations by POKORNY (1972) have revealed that it also causes damage in Czechoslovakia. Its presence in Denmark was reported by ROSTRUP (1911) at the beginning of this century. The damage it caused in France was described by RECAMIER (1964). The wheat bulb fly is also well known in Holland and Belgium (ANONYMOUS (1971). An account of its occurrence in Poland was given by MENDE (1974). In both East and West Germany it is considered to be a dangerous pest, as shown by a large number of literary works (FRANK 1900, KLEINE 1915, 1918, 1926, BÜRGER 1926, CRÜGER—KÖRTING 1931, KREYENBERG 1937, SOL 1963, 1964, 1972, BOLLOW 1960, 1964, BUHL—SOL 1963, 1964, LUTZE—MENDE 1972, WETZEL—MENDE 1972). According to MEIER (1976) the wheat bulb fly also occurs in Switzerland, while MIEGROET (1950) reports on the damage done by the wheat bulb fly in Belgium. According to MASKELL—DAVIS (1974) this pest can be found in Norway and even in some parts of the Soviet Union.

In Hungary literary references to the wheat bulb fly have only appeared since 1970. According to KÜKEDI (1975) attention was first called to damage caused by the wheat bulb fly at the Agricultural Research Institute of the Hungarian Academy of Sciences in Martonvásár where the pest did considerable harm in the wheat experiments. KUPAI (1974), SZEGÉNY (1975) and SZEŐKE (1979) reported on losses caused by the wheat bulb fly in farms.

KÜKEDI (1975) gave an account of how the wheat bulb fly was identified. Observations on the then unknown fly species had been collected since 1971 and contact was made with Dr. Tibor Jermy, the cereal fly specialist at the Research Institute for Plant Protection. On the basis of local surveys and the examination of larvae, pupae and adults collected or bred at Martonvásár, Jermy established the fact that the damage was caused by *Leptohylemyia coarctata* Fall. (Thanks are once again expressed for the identification.)

Damage. According to BUHL—SOL (1967) the larvae come to the surface early in spring, at the end of February, and seek for suitable host plants. When they find them they penetrate the stem above the tillering zone and chew the shoots in the centre while moving spirally upwards. The central leaves of the shoots affected first become yellow, then die.

A single larva may destroy several shoots. According to BOLLOW (1964) one larva destroys 6—10 shoots. In experiments carried out of CRÜGER—KÖRTING (1931) the number of shoots destroyed by each larva was 8—12. Other authors (GOUGH 1947, TOLDAEV 1967) reported the destruction of only 5 shoots. In WETZEL's (1971) studies one larva destroyed 2—3 shoots. This author established that an average of 2—4 shoots were destroyed by one larva. On the basis of experiments carried out in Switzerland MEIER (1976) recorded a loss of 3—4 shoots.

According to LUTZE (1974) the extent of damage done in the farms depends primarily on the abundance of eggs. In the case of 80—100 eggs per m^2 the prospective loss of shoots is about 8%, while with a large number of eggs (800/m^2) it may be as much as 30—40%. His observations show that a 100/m^2 increase in the number of eggs leads to an extra 4—5% loss of shoots. He registered an average 4.2% yield loss for 100 eggs/m^2. However, the yield loss depends not only on the abundance of eggs, but is also influenced by agrotechnical factors (sowing date, amount of seed, nutrient supply). Cereals sown late suffer more from the same extent of larval infestation. In their experiments LUTZE—MENDE (1972) found that 22—27% of the shoots were damaged in wheat sown late (on 29th October) and 30% of the stand was destroyed. On the other hand, in wheats sown early the damage to the shoots was only 12% and all the plants survived.

According to BUHL—SOL (1967) the stronger and thicker the wheat or rye plant, the greater the difficulty encountered by the larvae in penetrating the stalks and the slighter the damage. If a single stalk of an abundantly tillering wheat plant is destroyed, that is no real loss. LUTZE—MENDE (1972) determined the critical number of eggs and found that for well developed stands this value was 100—130 eggs/m^2, while for poor stands it was 80/100 eggs/m^2. Under favourable agrotechnical and meteorological conditions the plants compensate for the losses to be expected from an egg number below the critical value.

On the basis of experiences gained in Hungary KÜKEDI (1975) pointed out a close relation between unfavourable weather and the damage caused by wheat bulb flies. As an example he mentioned the dry March of 1974, when larva damage far exceeded the extent of tillering and shoot growth (the damage caused by wheat bulb flies is shown in Figs 1, 2 and 3). In the course of investigations made in Fejér county (Transdanubia) KUPAI (1974) found severe wheat bulb fly infestation in the farms, affecting more than 3000 ha wheat. SZEŐKE

Fig. 1. Wheat bulb fly damage in the experiments

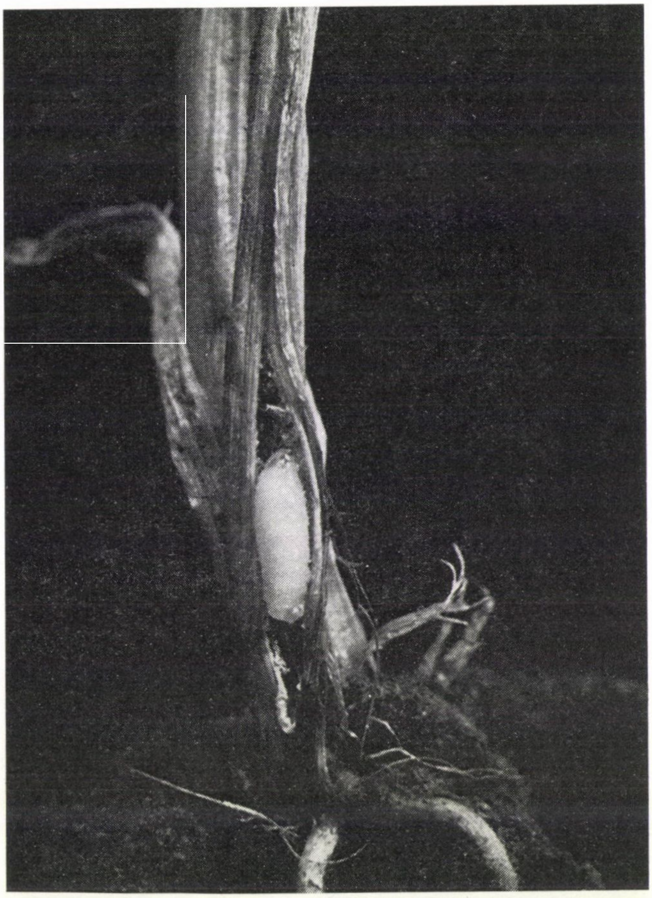


Fig. 2. Damage done by the wheat bulb fly larva

(1979) also demonstrated the importance of the weather, and drew the conclusion that the damage done by the insect population varied with the weather conditions.

Forecrop, host plant. The relation between the wheat bulb fly and the forecrop was dealt with in detail by BUHL—SOL (1967), who found that the wheat bulb fly usually lays its eggs in fallow fields or in potato, sugar-beet, carrot and clover crops, but may also be observed after other forecrops (cereals, etc.).

According to BARDNER *et al.* (1973) and MASKELL—DAVIS (1974) the wheat bulb fly prefers fallow land. BUHL—SOL (1967) found it caused the greatest damage in wheat, rye and winter barley, though it may also affect spring barley and oats. MÜHLE—WETZEL (1969) reported the occurrence of wheat bulb fly in grasses *(Bromus inermis, Phalaris arundinacea, Phleum pratense, Poa pratensis)*. According to a paper by GOUGH (1946) the species *Festuca, Lolium* and *Agrostis* are also exposed to wheat bulb fly infestation.

In Hungary KÜKEDI (1975) found that wheat bulb fly occurred after the following forecrops: pea, wheat, sugar beet, maize, winter barley, spring barley, Sudangrass and oats, whereas KUPAI (1974) did not find any plants infested by wheat bulb fly larvae when sown after maize.

Etiology. The occurrence and morphology of the wheat bulb fly have been dealt with by many authors (FRANK 1900, JEGEN 1932, BOLLOW 1960, MÜHLE—WETZEL 1969, LUTZE—MENDE 1972, BUHL 1963, BUHL—SOL 1963, MEIER 1976). According to the latter the wheat bulb fly has a single generation a year. The larvae overwinter in the soil at the L 1 stage and emerge at the end of February or in March. During the first 5—6 days they can live without feeding. After emergence they search for a suitable host plant, and on finding one, penetrate the stem above the tillering zone and begin to chew.

According to MEIER (1976) the larval stage lasts for about 10 weeks, then the larvae bury themselves in the upper soil layer, in the root zone, and enter the pupal state. In Switzerland the flies emerge at the beginning of June. In the German Democratic Republic LUTZE—MENDE (1972) found between 1968 and 1970 that the flies appeared in the field in June, mostly in the early morning hours, between 5 and 7 a.m. The males preceded the females. The highest abundance was observed at the time of wheat flowering.

Under greenhouse conditions the sex ratio was 50% male, 50% female, but in the field the males outnumbered the females. According to JONES (1971) the time of mass appearance depends on the weather. In Rothamsted, England, for example, the peak was in the first

Fig. 3. Damage done by the wheat bulb fly larva

week of July in 1967 and somewhat earlier, at the end of June, in 1968, while in 1969 two peaks were observed: one in the first week of July and the other between 15th and 20th of the same month. According to BUHL (1963) and BUHL—SOL (1963), in the neighbourhood of Braunschweig (West Germany) some wheat bulb flies appeared at the end of May but most were observed in June.

In Hungary KÜKEDI (1975) found wheat bulb flies in large numbers at the end of May in 1974 and around 10th June in 1975 and 1976, while in 1977 and 1978 the peak was some 10 days earlier than in 1974. As KUPAI (1974) reported the appearance of wheat bulb flies in Hungary begins by the end of May and may be completed by mid-June. SZEŐKE (1979) reports that wheat bulb flies were caught as early as 29th April in 1974, though mass swarming took place in the first half of June.

Feeding, lifespan, flying distance. According to JONES (1971) the wheat bulb fly requires space to move about in, water and food if it is to survive in the laboratory. In the field these conditions are, of course, provided for the adults. In his experiments Jones fed wheat bulb flies caught in the field on carbohydrates, fats and proteins; for this purpose he used various materials (flowers, honey, honey dew secreted by aphids, fungal spores). In female wheat bulb flies fed artificially in this way he found mature eggs after 24—27 days. In experiments carried out in the German Democratic Republic, MENDE (1974) used fungal spores (*Septomyxa affinis* Cohn.) as artificial food. BUHL—SOL (1963) caught wheat bulb flies with colour traps, then studied their lifespan under laboratory conditions. In his experiments the males lived for 50 and the females for 82—160 days. The investigations also revealed that the wheat bulb flies did not usually fly to a depth of more than 200 m from the edge of the fields. According to investigations by MENDE (1974) the number of eggs laid shows a definite decrease after a distance of 100 m from the edge of the field. Also, he observed that in spite of the fact that during their long lives (May—October) the females sometimes got quite far from their place of emergence they hardly ever flew more than 500 m in from the edge of the field.

The above findings on the flying distance of wheat bulb flies are not confirmed by observations made in Hungary; in plots ploughed up because of larval damage severe plant losses were found not only at the edges but also farther in.

Oviposition, egg number. According to LUTZE—MENDE (1972) the eggs in the ovary become mature in about 4 weeks and oviposition generally lasts for 4—8 weeks. In the German Democratic Republic it usually begins in the last ten days of July and reaches a peak at the end of the month. In August the oviposition is completed.

In experiments carried out over a 7-year period in the German Federal Republic, SOL (1963) found that oviposition began at the end of June, peaked in July and was completed in August. On the area observed, wheat bulb flies were in flight from the end of May until the beginning of October, and laid their eggs in the months mentioned in cracks in the soil at a depth of several centimetres. The investigations of SOL (1963) basically confirmed the research results of BÜRGER (1926) and KLEINE (1926) who reported July and August as the date of oviposition. A female generally lays 30—50 eggs. GOUGH (1953) and LONG (1958) also found that 50 eggs per female could be expected. EDWARDS—HEATH (1964) similarly established that the female wheat bulb fly laid 30—50 eggs in cracks in the soil in July and August. Speaking about oviposition JONES (1971) notes that the females usually lay 1—2, sometimes 3 clumps of eggs. The results obtained by MENDE (1974) in detailed examinations on eggs are shown in Table 1. According to the data in the Table, the second half of July and the month of August are the peak periods of oviposition in the German Democratic Republic. In 1969 an unusually large number of eggs was laid in September, but in the following two years no eggs were found in September. In the German Federal Republic oviposition begins by the end of June, and 90% of the eggs are laid within a month (ANONYMOUS 1971). On the basis of investigations carried out in Switzerland MEIER (1976) states among other things that

Table 1

Number of eggs in experiments carried out in the German Democratic Republic
(1969, 1970, 1971)

Year	July		August		September	
	15th	29th	12th	26th	9th	23rd
1969	—	205	240	150	55	10
1970	—	110	85	15	—	—
1971	60	137	150	17	—	—

Table 2

Number of dried, sterile and parasite-infested eggs

Year	Number of eggs examined	Number of		
		dried	sterile	parasite-infested
		eggs		
1962	1909	3	3	2
1963	901	11	2	2
1964	3784	18	4	3
1965	755	5	4	0
Average	—	9	3	2

oviposition begins in July and lasts until September. This author found that a female produces 30—50 eggs, though under extremely favourable conditions it may lay as many as 200 eggs. In Hungary Kupai (1974) found July to be the main time of oviposition. Szeőke (1979), on the other hand, demonstrated that oviposition began in Hungary in June, continued in July and was completed by September. This author found an average of 31 eggs in the ovaries.

Destruction of eggs. According to Sol (1972) a considerable proportion of the eggs are destroyed. The rate of destruction depends on the weather and on other circumstances. In his experiments 18% of the eggs dried up in 1964. In the rainy year of 1965, on the other hand, the proportion of eggs thus spoiled was only 5%. The highest porportion of drying up in his experiments was 35%. The author found, however, that the destruction of the eggs depended not only on the weather but also on soil cultivation. The proportion of eggs which dried up was considerably lower when the soil was ploughed after oviposition. In the opposite case, especially in dry summers, a considerable proportion of the eggs dried up and were destroyed. In the experiments of Bardner *et al.* (1973) the proportion of specimens developing from the eggs laid ranged from 7 to 28%, the average being 15%. According to Way (1959) the reduced number of larvae may be due not only to drying, but also to sterility. In his experiments the proportion of sterile eggs was 11%. The results of his investigations are summed up in Table 2.

As seen from the data in the Table, the number of eggs destroyed changes mainly as a function of drying. The number of sterile and parasite-infested eggs does not vary much from year to year. RYAN (1973) studied the causes of egg mortality with special regard to parasite infestation. In his experiments he found the loss from oviposition to the emergence of the larvae to be insignificant. None of the 3000 eggs examined was infested by parasites, and signs of disease were only shown by 1%. The proportion of sterile eggs, on the other hand, was considerable, ranging from 2 to 14%. Further, his investigations revealed that nearly half of the *Carabidae* species cause damage to the eggs. In an earlier paper DOBSON (1961) reported on similar experiences and mentioned that members of the *Forficulidae* family were observed to eat the eggs.

Larval development and the enemies of the larva. The development of the larva has also been described by many authors (MORRIS 1925, GEMMILL 1927, MÜHLE—WETZEL 1969, MEIER 1976). A detailed description is given by LUTZE—MENDE (1972). According to BUHL—SOL (1967) the larvae are fully developed 2 weeks after oviposition, having reached larval stage L 1, but do not leave the egg until February or March. WETZEL—MENDE (1972) also report that larval development begins immediately after oviposition and continues until the diapause sets in at about larval stage L 1. The diapause lasts until immediately before the larvae emerge from the eggs in February or March. According to LUTZE—MENDE (1972), when the larva appears is 1.3 mm long and 0.4 mm wide. The larvae have 3 development stages and moult twice in the meantime. At the last stage they are 6.5—7 mm long. GEMMILL (1927) describes larvae 10—11 mm long, while ANONYMOUS (1971) states that the fully developed larvae are 7—8 mm long and 2 mm wide, and yellowish-white in colour. As seen from the results of detailed investigations carried out by LUTZE—MENDE (1972) a considerable proportion of the larvae perish for various reasons. In their experiments they observed a 40—60% mortality rate between oviposition and the pupal stage. This high mortality was mostly due to drying

Fig. 4. Wheat bulb fly pupae

up, sterility and parasite infestation. DOBSON (1961) mentions *Trybliographa spaniandra* (Kerrich et Quinlan) as the most important parasite of the larvae. SOL (1972), referring to other authors, also mentions other enemies of the larvae, noting at the same time that not only the larvae, but the pupae and even the adults have their natural enemies.

Pupal state. According to MASKELL–DAVIS (1974) the fully developed larvae leave the plants and move into the soil to the root zone of the plants to form a chrysalis. The pupa is smaller than the larva. The colour of the pupa is brown at first, becoming dark brown later. In the German Federal Republic the pupal state lasts from about the end of April to the end of May, or to the beginning of June at the latest. As shown by the examinations of LUTZE–MENDE (1972) the average length of the pupa is 5.9 mm and the width 1.9 mm. The smooth-surfaced, glittering pupa is first brownish-grey, and later becomes dark brown, then blackish-brown (the fully developed pupae are shown in Fig. 4).

Control. In KÜKEDI's (1975) opinion the natural enemies of the wheat bulb fly are too few in number to control the pest, so every possibility for complex, integrated control must be exploited. LUTZE–MENDE (1972) summarized the most important features of control, referring to proper crop rotation and the importance of choosing the right forecrop. Attention had previously been called to the possibilities inherent in the latter by other authors (KLEINE 1918, GEMMILL 1923, GOUGH 1953, 1957a, 1957b, BOLLOW 1960). In the opinion of these authors, it is not advisable to sow autumn cereals on areas infested by wheat bulb fly after fallow, potato, sugar beet or clover forecrops.

LUTZE–MENDE (1972) also discuss soil cultivation, though they note that the number of larvae could not be reduced by ploughing the eggs 15–25 cm deep into the soil. Careful soil cultivation, however, where the earth is worked as it is in a garden is not favourable to oviposition, so this possibility should be exploited.

LUTZE–MENDE (1972) also call attention to the possibilities inherent in growing abundantly tillering varieties. These varieties possess a high ability to compensate and overcome damage below the critical value.

The authors analyse the importance of the sowing date with special care and indicate the disadvantages involved in late sowing. There can be no doubt that weak stands which emerge late and show little or no tillering have very low tolerance of damage. Crops sown at the optimum time, on the other hand, compensate for a large part of shoot losses.

A number of authors attach great importance to a moderate increase (10–15%) in the amount of seed (ROSTRUP 1911, GEMMILL 1923, RAW 1954, 1960).

GEMMILL (1923), GOFFART (1934) and RAW (1960, 1967) call attention to the wide possibilities offered by fertilization. Some authors attach particularly great importance to nitrogen top dressing from the point of view of control. According to experiences gained in Hungary a sufficient supply of nutrients increases the regenerating and compensating ability of grain crops.

LUTZE–MENDE (1972) also call attention to chemical control. They note, however, that without a good prognosis it is difficult to decide on the necessity of chemical control. For this reason they have elaborated a forecasting system on which the chemical control of wheat bulb fly is based. Many authors (BARDNER–KENTEN 1957, BARDNER 1959, BUHL–SOL 1963, POKORNY 1972, LUTZE–MENDE 1972, MASKELL–DAVIS 1974, ANONYMOUS 1971, KÜKEDI 1975) are in almost complete agreement as to the success of seed dressing. This method of control is considered to be cheap, economical and of a preventive nature. MEIER (1976), while admitting the advantages of seed dressing, calls attention to the adverse effects of this method of control (toxic effect on warm-blooded organisms, phytotoxic effect on seedlings). In Hungary KÜKEDI (1975) found Basudin seed dressing to be effective against the wheat bulb fly, but since treated seeds left on the surface of the soil caused great damage to birds its use had to be stopped.

Table 3

Number of shoots destroyed, and trend of yield
(Martonvásár, 1975, 1976, 1977)

Treatment	lit/ha kg/ha g/q	Active agent	Number of shoots destroyed per m²			Yield, q/ha		
			1975	1976	1977	1975	1976	1977
1. Control	—	—	17	2	10	52.9	61.6	45.9
2. Basudin 10 G	20	diasinon	6	3	9	51.6	65.3	45.9
3. Basudin 10 G	40	diasinon	3	4	5	56.4	65.8	47.3
4. Basudin 10 G seed diessing	20	diasinon	9	5	—	53.9	61.5	44.8
5. Basudin 10 G seed diessing + Quinolate 15	20	copper-oxy-quinolate	3	4	10	54.0	64.8	42.6
6. Dimecron 50 E.C.	0.4	phosphamidon	31	3	11	53.7	63.0	42.5
7. Ditrifon 50 WP	1.4	trichlorophon	19	5	11	53.7	62.9	41.4
8. Birlane 25 WP	0.5	chlorophenvinphos	36	8	15	51.6	64.8	46.1
		$LSD_{5\%}$				2	1.1	2.2

Opinions also agree as to the beneficial effect of soil sterilization (Bonnemaison 1960, Buhl—Sol 1963, Gough *et al.* 1961, Maskell—Gair 1961, Lutze—Mende 1972, Kükedi 1975, Szeőke 1979). Nevertheless, most of the authors remark that it is a very expensive method of control and can only be economically applied when the number of eggs per m² is above the critical value.

In an experiment at Martonvásár soil sterilization proved to be a successful method of controlling the wheat bulb fly, as shown by the data in Table 3.

The data in the Table reveal that the shoot damage per m² was well below the critical value in all three years of the experiment. It was also established that soil sterilization with 40 kg/ha Basudin was able to reduce the number of infested shoots to a considerable extent. At such a low rate of destruction the economic efficiency of soil sterilization may be questionable, but on an experimental area this operation can seldom be dispensed with because of soil-borne pests. It is difficult to evaluate the crop results shown in the Table, because we do not know whether the yield differences were caused by the destruction of soil-borne pests or by a reduction in the number of wheat bulb flies. It is thus impossible to determine percentages. A further examination of the data of Table 3 reveals that chemical control early in spring was not successful in these experiments. The failure can be explained by the small number of larvae, the unfavourable weather prevailing at the time of spraying, and the low temperature. Information on good results which contradict these experiences can be obtained from the works of Maskell—Gair (1961) and Griffiths—Scott (1969).

The paper has summarized the bulk of the knowledge acquired so far in Europe concerning the wheat bulb fly, complemented with the results of observations made in Hungary. Investigations show that the wheat bulb fly has caused damage in Hungary since 1970, so damage must be expected in the future, too. In the fight against wheat bulb fly the best results can be expected from integrated control in which seed dressing plays a particularly important role.

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Prepared at the Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvásár. E. Kükedi

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IMPROVING TETRAPLOID MONOGERM SUGAR BEET POPULATIONS AND THEIR HYBRIDS FOR SEED CHARACTERS, ROOT YIELD AND TECHNICAL VALUE. II. SELECTION FOR DIFFERENT FRUIT SIZES

The multigerm fruit of beet is an aggregate, formed by the cohesion of two or more flowers grown together at their bases and forming a hard, irregular so-called seed ball or cluster, which usually contains 2 to 6 seeds. The fact that each cluster may give rise to several seedlings is a disadvantage when growing the crop. Two or more seedlings derived from the same cluster will be closely crowded together, and hand-singling is therefore necessary. Various methods of overcoming this difficulty have been tried. One of the most important developments in beet growing is monogermity. Initially a considerable improvement was achieved by using technically monogerm seed which was produced by mechanical treatment of the usual multigerm clusters (rubbing or segmenting). However, these methods caused mechanical damage to the seeds and sometimes the percentage of germination was decreased. The discovery of genetically monogerm plants was the most important breakthrough for the complete mechanization of the spring work in sugar beet production.

Monogerm character (one flower and only one germ for each fruit) should prove to be a great advance in sugar beet production. Numerous monogerm varieties have been developed and introduced into cultivation. Reduction in the seed rate for drilling has led to great changes in technique. Very low seed rates of specially treated seed are now widely employed. The low seed rates are sown with a precision or spacing drill. A technique was developed to sow at an even lower seed rate, spacing the seeds at a large distance and doing no thinning at all.

The monogerm "seed" is, however, rather irregular in shape and may be difficult to use in precision drills without special processing. The seed used with modern precision drills is rubbed and specially graded. A certain amount of seed is pelleted and all the pellets are made to the same size.

Various types of monogerm varieties are developed by the breeders. Heterosis and polyploidy are widely used in the breeding of monogerm sugar beet (FARAG—MAGASSY 1979).

The seed characters (seed size, germination, weight of fruits and germs, shape of seed) have great importance for completely mechanized production.

Multigerm populations have not been exposed to selection for seed characters. There are no indications in the literature concerning hereditary varietal differences in the seed characters of multigerm sugar beet. Selection for desirable characters in monogerm fruits is necessary to improve the seed quality. Monogermity has made it possible to select for improvement of many seed properties.

The weight of fruits and germs of monogerm beets is one of the factors determining the seed quality. In multigerm sugar beet varieties a high variation in weight of germs was observed within the seedball. The variability in weight of germs within the fruit of monogerm beets is impossible. The variability in weight of germs is determined by the variability of weight of fruit only in monogerm beets. The weight of germs is controlled by separation of seeds for different sizes in the monogerm populations. The weights of fruits and germs are increased by tetraploidy and a new genetic variability arises in the tetraploid populations. Therefore the possibilities of breeding for the weight of fruits are greater in tetraploid monogerms than in diploids (SAVITSKY 1952, SAVITSKY *et al.* 1954, DOXTATOR—HELMERICK 1962, FILUTOWICZ 1961, SAVITSKY—SAVITSKY 1965, RÖSTEL 1972b).

The significance of the size of fruits has aroused interest in agriculture for a long time. The size of fruit was used for studying the problem of heterosis. Seed size can be one of the manifestations of heterosis (ASHBY 1930, EAST 1936). As with most crops, early growth is related to seed size but the final yield is seldom affected (BLACK 1959, BLAESDALE 1966). AUSTENSON—WALTON (1970) stated that larger seeds must give more vigorous seedlings and this difference must be maintained throughout the life of the crop. SCOTT *et al.* (1974) suggested that there are two reasons why the use of large seed has a beneficial effect on sugar beet. First, any factor that affects field emergence is important. Second, large seeds produce large seedlings, the use of large seed may accelerate early growth and the production of a full leaf cover affording the possibility of high productivity. A positive correlation was determined between the different seed sizes of monogerm varieties and their germination percentage (CSAPODY 1964, EFREMOV 1968, CSAPODY—CSAPODY 1969, RÖSTEL 1972a, LONGDEN *et al.* 1974). The large fruits of monogerm beets have a greater emergence force and potential than small fruits (SNYDER—FILBAN 1970). Germination seems to be highly influenced by the weight of the pericarp related to the true seeds. The ratio of seed weight to pericarp weight is higher in diploids than in tetraploids (BOLELOVA—NEGOVSKY 1965, RÖSTEL 1967, CSAPODY—CSAPODY 1969). A positive correlation was observed between the different sizes of fruits and monogermity. The monogermity increased in small-sized fruits and decreased in large ones (RÖSTEL 1972a, LONGDEN *et al.* 1974). TEKRONY—HARDIN (1969) reported that the major cause of variable and poor seedling emergence was the occurrence of empty or underdeveloped seeds which might be less frequent in large-graded seeds.

Triploids are the most desirable level of ploidy. Multigerm triploid seed is generally produced from a seed mixture of the tetraploid and diploid parents after they have been crossed (anisoploid varieties). The open pollinated seed harvested will be a mixture of diploids, triploids and tetraploids. The percentage of triploids is higher than normally expected because selective fertilization is of common occurrence in beet (MAGASSY 1963). In the multigerm anisoploid varieties the percentage of triploids was increased by the screening of seedballs for size.

The seedballs of tetraploid parents are larger than the seeds of the diploid. The small seeds contain more diploids than the large ones. Therefore the separation of seeds for size may be an effective procedure for increasing the rate of triploids in the anisoploid multigerm varieties (BØGH 1954, FÜRSTE 1958, GRAF 1958, SCHNEIDER 1960, SEDLMAYR 1961, JØRGENSEN 1964, HETZER 1964).

In the multigerm polyploid varieties, earlier results showed that the yield of beet increased with an increase in seed size (SEDLMAYR 1961, HETZER 1964, JØRGENSEN 1964).

Table 1

1000 fruit weight, monogermity and germination of the fruit diameters of the tetraploid monogerm population M. 914

Fruit diameters, mm	Weight of 1000 fruits, g	Monogermity %	Germination %
2.0–2.5	10.25	100.0	17.0
2.5–3.0	14.74	99.0	60.0
3.0–3.5	18.47	98.2	86.0
3.5–4.0	23.79	83.1	91.0
>4.0	28.17	47.8	94.0
L.S.D. 5% ±	0.36	0.4	1.9

A strong correlation was also observed between the seed weight and root yield in the monogerm sugar beet varieties. The highest yield was produced by the highest seed weight (MOTYREV 1962, EFREMOV 1966, TISCENKO—JURKO 1967). The root yield was increased by discarding the small seeds but after the separation of the seeds no effect could be found on the sugar content (MACLACHLAN 1972, RÖSTEL 1972a). LONGDEN *et al.* (1974) and SCOTT *et al.* (1974) showed that the sugar yield of the smallest seeds was lower than that of the other grades of seeds.

In this study, the effect of seed grading on seed characters, yield and technical value of beet was investigated in a tetraploid monogerm population and its triploid hybrids, compared with the results of the monogerm tetra-tri variety (BETA poli M/102.).

Table 2

Root yield and technical value of the fruit diameters

Location: Sopron-

Fruit diameters, mm	Root yield 1975 t/ha	Root yield 1975 rel.%	Root yield 1976 t/ha	Root yield 1976 rel.%	Sugar content 1975 %	Sugar content 1975 rel.%	Sugar content 1976 %	Sugar content 1976 rel.%
2.0–2.5	38.89	88.43	23.17	92.64	14.38	100.00	15.27	100.33
2.5–3.0	43.80	99.59	24.47	99.04	14.38	100.00	15.57	102.30
3.0–3.5	43.98	100.00	25.04	100.12	14.33	99.65	15.27	100.33
3.5–4.0	44.17	100.43	25.43	101.68	14.38	100.00	15.50	101.84
>4.0	44.54	101.27	25.95	103.76	14.38	100.00	15.39	101.12
M. 914	43.98	100.00	25.01	100.00	14.38	100.00	15.22	100.00
L.S.D. 5% ±	1.83	4.17	1.89	7.56	0.17	1.18	0.45	2.96

In 1975 the fruits of the tetraploid monogerm population M. 914 and the monogerm tetra-tri variety BETA poli M/102 were sized using slot hole screens with different diameters (2.0–2.5, 2.5–3.0, 3.0–3.5, 3.5–4.0 and >4 mm). (M. 914 is the tetraploid monogerm seed parent of BETA poli M/102.)

The seed fractions were investigated for the weight of 1000 fruits, monogermity and germination. In 1975 and 1976 the different seed sizes were tested for root yield and technical value in a field trial.

In the autumn of 1975, 90 beets were selected in the plants grown from fruits of tetraploid monogerm M. 914 with different diameters. During the winter of 1975/1976, these beets were preserved in a pile covered by soil and in the spring the beets were planted out and crossed with the diploid multigerm E.III, which is the pollinator for the production of the commercial variety BETA poli M/102. The seeds of the hybrids produced on the progeny of the different seed sizes of tetraploid monogerm M. 914 were investigated for the weight of 1000 fruits, monogermity and germination. In 1977, the hybrides were tested for yield and technical value in a field experiment.

All these experiments were conducted at the Research Institute for Sugar Beet in Sopronhorpács. A randomized block design with six replications was used in each field experiment. The plots consisted of three rows 10 m long, spaced 45 cm apart: plants within rows were 20 cm apart and the usual care was given to them during the growing season.

For the cytological analysis, 500 seeds were tested in each treatment. The seeds were wrapped up in moist filter paper and germinated at 26°C. The root tips were fixed in Carnoy and stained with aceto-carmine. The laboratory tests for germination, monogermity and 1000 fruit weight were carried out in five replications.

The sugar yield in 1975 and the extractable sugar yield in 1976 and 1977 were calculated by the formula which was reported in a previous publication.

The effect of seed grading on the seed characters, root yield and technical value of tetraploid monogerm population M. 914. Table 1 shows a strong relation between the fruit size and other seed characters. The highest weight of 1000 fruits and germination were found

of the tetraploid monogerm population M. 914

horpács, 1975–1976

Conductometric ash content in 1975		Potassium in 1976		Sodium in 1976		Amino-nitrogen in 1976		Extractable sugar production			
								1975		1976	
%	rel.%	meq/100 g beet	rel.%	meq/100 g beet	rel.%	meq/100 g beet	rel.%	t/ha	rel.%	t/ha	rel.%
0.52	**89.66**	6.11	103.91	1.98	110.61	6.49	105.02	4.350	89.08	2.689	91.68
0.54	93.10	5.75	97.79	1.64	91.62	6.40	103.56	4.887	100.08	2.963	101.02
0.56	96.55	5.80	98.64	1.80	100.56	5.61	90.78	4.870	99.73	2.963	101.02
0.54	93.10	5.80	98.64	1.73	96.65	5.97	96.60	4.924	100.84	3.067	104.57
0.57	98.28	5.65	96.09	1.77	98.88	6.31	102.10	4.946	101.29	3.104	105.83
0.58	100.00	5.88	100.00	1.79	100.00	6.18	100.00	4.883	100.00	2.933	100.00
0.05	8.62	0.38	6.46	0.30	16.76	0.67	10.84	0.201	4.12	0.253	8.63

in the largest seed diameter. Fruit weight and germination decreased gradually with the reduction of fruit size. Monogermity was complete in the smallest fruit size and showed a gradual decrease with enlarging fruit size.

The root yield and technical value of beets was studied in fruits of different diameters for 2 years (Table 2). The smallest class of fruits gave the lowest yield and extractable sugar production. The difference was significant between the smallest class and the other fractions. No significant differences could be identified among the other diameters of fruits but a rising tendency exists for the yield and extractable sugar production in the large diameter classes. The fruit size had no effect on sugar content. The results showed no clear differences in conductometric ash, potassium, sodium and amino-nitrogen content among the fruit in different diameter classes. The large fruit diameters yielded more than the control M. 914 but the differences were not significant.

Seed characters, root yield and technical value of hybrids produced on the progeny of different fruit diameter classes in a tetraploid monogerm population by crossing with diploid multigerm pollinator. Table 3 presents the results of the investigations for seed characters of the hybrids. The differences between the hybrids were significant for the weight of 1000 fruits but not in every case for monogermity and germination. The lowest fruit weight and germination were given in the hybrid produced on progeny in the smallest diameter class and these increased gradually in hybrids produced in the large fruit diameter classes. A slight reduction of monogermity was observed in the hybrids of the large diameter classes. The results showed slight differences in the seed quality of hybrids produced on the progeny from different fruit diameter classes, while great differences were found in the tetraploid monogerm parent (Table 1). No appreciable differences were determined among the triploid percentages of the different hybrids. No significant differences could be identified among the different hybrids in root yield, sugar content and extractable sugar production (Table 4). Also, there were no differences between the properties of different hybrids and the commercial variety BETA poli M/102.

The effect of fruit diameters of the commercial variety BETA poli M/102 on seed characters, root yield and technical value. The data in Table 5 indicate large differences in seed properties resulting from the different fruit sizes. Fruit weight and germination increased gradually with the increase in fruit diameter. Complete monogermity (100%) was observed in

Table 3

Seed characters of hybrids produced on the progeny of different fruit diameter classes of a tetraploid monogerm population by crossing with a diploid multigerm pollinator

Hybrids produced on the progeny of different fruit diameters, mm	Weight of 1000 fruits, g	Monogermity	Germination	Triploid	Tetraploid
		%			
2.0–2.5	18.12	95.4	78.0	84	16
2.5–3.0	18.34	96.2	80.0	86	14
3.0–3.5	18.57	95.8	79.0	86	14
3.5–4.0	18.87	94.8	81.0	85	15
>4.0	19.20	92.5	81.0	83	17
L.S.D. 5% ±	0.19	1.5	2.1		

Table 4

Root yield and technical value of hybrids produced on the progeny of different fruit diameter classes of a tetraploid monogerm population by crossing with a diploid multigerm pollinator

Location: Sopronhorpács, 1977

Hybrids produced on the progeny of different fruit diameters, mm	Root yield		Sugar content		Potassium	
	t/ha	rel.%	%	rel.%	meq/100 g beet	rel.%
2.0—2.5	38.02	99.32	17.12	99.36	5.10	102.82
2.5—3.0	38.07	99.45	17.18	99.71	5.14	103.63
3.0—3.5	38.20	99.79	17.16	99.59	5.42	109.27
3.5—4.0	38.07	99.45	17.25	100.12	5.21	105.04
>4.0	38.48	100.52	17.24	100.06	5.35	107.86
BETA poli M/102	38.28	100.00	17.23	100.00	4.96	100.00
L.S.D. 5% ±	3.03	7.91	0.45	2.61	0.48	9.68

Hybrids produced on the progeny of different fruit diameters, mm	Sodium		Amino-nitrogen		Extractable sugar production	
	meq/100 g beet	rel.%	meq/100 g beet	rel.%	t/ha	rel.%
2.0—2.5	0.86	98.85	3.82	94.79	5.489	98.55
2.5—3.0	0.81	93.10	3.44	85.36	5.533	99.34
3.0—3.5	0.85	97.70	4.02	99.75	5.481	98.40
3.5—4.0	0.77	88.51	3.97	98.51	5.533	99.34
>4.0	0.87	100.00	3.72	92.31	5.570	100.00
BETA poli M/102	0.87	100.00	4.03	100.00	5.570	100.00
L.S.D. 5% ±	0.16	18.39	0.46	11.41	0.424	7.61

the smallest diameter class. The monogermity decreased gradually in the large fruit diameter classes. The highest triploid percentage was determined in the medium fruit diameter class (3.0—3.5 mm) and decreased for both small and large fruit diameters.

The effect of the different fruit diameters on yield and technical value are presented in Table 6. During 2 years of experiments, the root yield in the smallest diameter class (2.0 2.5 mm) was significantly less than the yield in the other classes. In 1975 a significant reduction of the extractable sugar production was observed in the smallest diameter class. In 1975 the differences in extractable sugar production were not significant among the different fruit

Table 5

Weight of 1000 fruits, monogermity, germination and hybridization of the fruit diameters of the variety BETA poli M/102

Fruit diameters, mm	Weight of 1000 fruits, g	Monogermity	Germination	Triploid	Tetraploid
		%			
2.0—2.5	10.92	100.0	58.4	72.6	27.4
2.5—3.0	13.67	98.8	73.0	77.0	23.0
3.0—3.5	15.75	97.0	84.4	81.6	18.4
3.5—4.0	18.48	89.6	88.4	71.0	29.0
4.0—5.0	21.73	79.0	94.0	66.4	33.6
>5.0	23.53	48.2	90.0		
L.S.D. 5% ±	0.62	1.2	1.5		

diameter classes but there was an appreciable reduction in the smallest diameter class. The results showed there were no effects of fruit grading on the sugar content.

The seed grading of a tetraploid monogerm population had a considerable effect on the seed characters and root yield. A strong positive relationship was observed between the large fruit diameter, the fruit weight and germination, while a negative relation was found between the large fruit diameter and monogermity. Root yield and extractable sugar production slightly increased with the increase in fruit diameter. Fruit size had no effect on sugar content.

Table 6

Root yield and technical value of the fruit diameters

Location: Sopron-

Fruit diameters, mm	Root yield				Sugar content			
	1975		1976		1975		1976	
	t/ha	rel.%	t/ha	rel.%	%	rel.%	%	rel.%
2.0—2.5	51.02	95.67	24.35	93.44	14.20	99.65	15.45	99.36
2.5—3.0	53.15	99.66	25.76	98.85	14.23	99.86	15.54	99.94
3.0—3.5	53.43	100.19	26.16	100.38	14.30	100.35	15.60	100.32
3.5—4.0	53.98	101.22	26.43	101.42	14.28	100.21	15.53	99.87
4.0—5.0	54.35	101.92	26.72	102.53	14.28	100.21	15.45	99.36
BETA poli M/102	53.33	100.00	26.06	100.00	14.25	100.00	15.55	100.00
L.S.D. 5% ±	1.63	3.05	1.15	4.40	0.54	3.79	0.26	1.67

A slight difference in seed quality and no differences in root yield and technical value have been found among the hybrids which were produced on the progeny of different fruit diameter classes in a tetraploid monogerm population. It could be concluded that separation for fruit sizes does not involve separation of different genotypes and different maturity stages. The selection for large fruit diameter at tetraploid level does not increase the yielding capacity and technical value of triploid hybrids produced on them. It could be said that selection for biotypes differing in flowering time is very effective for improving the seed quality and the productivity of monogerm beets.

Seed grading for the commercial variety BETA poli M/102 showed that the seed quality and yielding capacity might be improved by the discarding of the smallest and largest fruit diameter classes.

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Prepared at the Research Institute for Sugar Beet, Sopronhorpács.

M. A. Farag, L. Magassy

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of the commercial variety BETA poli M/102

horpács, 1975—1976

Conductometric ash content in 1975		Potassium in 1976		Sodium in 1976		Amino-nitrogen in 1976		Extractable sugar production			
								1975		1976	
%	rel.%	meq/100 g beet	rel.%	meq/100 g beet	rel.%	meq/100 g beet	rel.%	t/ha	rel.%	t/ha	rel.%
0.58	100.34	5.90	103.69	1.88	108.05	6.50	99.39	5.563	95.19	2.889	91.77
0.57	98.79	5.67	99.65	1.72	98.85	6.38	97.55	5.822	99.62	3.126	99.30
0.52	90.17	5.47	96.13	1.54	88.51	6.06	92.66	5.933	101.52	3.230	102.60
0.55	95.34	5.84	102.64	1.74	100.00	6.46	98.78	5.963	102.04	3.185	101.18
0.55	94.48	5.72	100.53	1.63	93.68	6.06	92.66	6.007	102.79	3.222	102.35
0.58	100.0	5.69	100.00	1.74	100.00	6.54	100.00	5.844	100.00	3.148	100.00
0.03	5.17	0.25	4.39	0.50	28.74	0.49	7.49	0.349	5.97	0.519	16.49

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REGULATION OF THE DEVELOPMENT OF WINTER WHEAT VARIETIES USING LOW TEMPERATURES

In a controlled environment the heading dates of varieties with different vegetation periods show greater differences than in the field. In order to cross such varieties their development must be regulated to achieve nicking in the flowering times. This can be done by modifying two factors, one of which is the length of illumination, the other the temperature. In the present investigations the effect of four temperatures on the heading date was examined.

The direct effect of heat on plant growth has been the subject of investigation for a long time (SACHS 1860, BARANETZKY 1879), but it was not until the phenomenon of thermoperiodism was observed that research became intense (RADCHENKO 1936, 1940, TETYUREV 1939, ARTHUR—HARVILL 1941, WENT 1944).

Many authors have studied the effect of temperature on the growth and development of wheat, paying particular attention to grain development at various temperatures (FRIEND 1965, WARDLAW 1970, SOFIELD *et al.* 1974, KOROVIN—KOZLOV 1978).

Recently, the grain formation of spring wheats has been studied after applying different temperatures at various stages of the vegetation period (WARRINGTON *et al.* 1977, KOLDERUP 1979). It has been established that varieties respond differently to temperature (CANVIN—YAO 1967, KOLDERUP 1974). However, few data are available in the literature on factors affecting the vegetation period of winter wheat varieties.

The investigations were carried out in the phytotron at the Agricultural Research Institute of the Hungarian Academy of Sciences in Martonvásár. In this series of experiments four temperature treatments were used to study the regulation (retardation) of development. These were as follows:

— control, i.e. the normal temperature used for raising plants. This varies between 16/15 and 24/18°C (day/night) from planting to maturity (BALLA 1980).
— −3°C = 3°C lower than the normal programme
— −6°C = 6°C lower than the normal programme
— −9°C = 9°C lower than the normal programme

The illumination was produced by Gro-Lux/WS and Cool White fluorescent tubes, gradually increasing from 13 hours 15 minutes to 16 hours. The light intensity was 20—25 thousand lux (400 μE/m^2/sec).

Three wheat varieties of different origin and with different vegetation periods were chosen for the examinations:

Sadovo 1: an early, winter hardy variety of southern origin. Pedigree: Jubileinaya III × Bezostaya 1. Bred at Sadovo, Bulgaria.

Bezostaya 1: a midseason, winter hardy variety introduced into Hungary. Pedigree: Lutescens 17 × Skorospelka 2. Bred at Krasnodar, Soviet Union.

Maris Huntsman: a late, winter hardy variety of northern origin. Pedigree: (CI 12644 × Capelle D.$_5$) × Hyb 46 × (Capelle D. × Prof. Marchal$_2$). Bred at Cambridge, England.

The seeds of the varieties were germinated in Petri dishes, then planted in plastic tubes and vernalized for 45 days in a chamber at 2°C under weak blue illumination. The plants were then transferred to pots and placed in a phytotron chamber (GB), where they were raised on the normal programme devised by S. and E. Rajki (for details, see BALLA

1980). The treatments were carried out on the basis of the Feekes scale of development. When plants raised on the normal programme reached the required developmental phase, they were transferred to another chamber (E 15 VH) with identical illumination but with a lower temperature, as foreseen by the treatment. The plants were kept there until they had completed the relevant phase of development.

The treatment can be divided into three groups:

1. Treatment over two developmental phases (1—2, 3—4, 5—6, 7—8 or 9—10).
2. Treatment over four or six developmental phases (1—4, 5—8 or 5—10).
3. Treatment from planting to heading (1—10.1).
4. Control, raised on the normal programme.

Each treatment consisted of 10 plants. The effect of temperature on the course of development was determined by observing the heading date (days from planting to heading). The plants were kept under observation for 95 days, after which the examination was terminated.

As a result of twice daily watering and a regular supply of nutrients 2.5—3.5 normally sized ears were obtained on average on each plant.

The various temperature treatments affected the heading dates of the varieties to a different extent (Table 1).

Sadovo 1, which headed after 53 days on the normal programme, gave little or no response to low temperature. A temperature 3 or 6°C lower than that of the normal programme in phases 1—2, 3—4, 5—6, 7—8 or 9—10.1 had no effect on the heading date. If the temperature was lowered by 9°C the variety headed 2—6 days later.

A temperature 3°C lower than normal in developmental phases 1—4 had no effect either, while a reduction of 6 or 9°C in the temperature only caused a delay of 2 or 9 days respectively. The effect of the treatment was greater if the treatment was carried out in phases 5—8 or 5—10 (3—18 days' delay). The greatest effect was, of course, recorded for a continual reduction in temperature: if Sadovo 1 was kept at a temperature 9°C lower than normal it failed to head even after 95 days.

Bezostaya 1 responded more intensely to low temperature. In developmental phases 5—6, 7—8 or 9—10 a reduction of 3°C in the temperature caused a significant difference in the heading date, delaying it by 6—8 days compared to the control. A temperature 6°C lower than normal was effective from the third phase onwards, while a 9°C reduction in temperature was effective from the first phase onwards. If the treatment was continued over four developmental phases, only a reduction in temperature of 3°C remained ineffective. Heading was latest (32 days later than the control) if the treatment was carried out during phases 5—10 at 9°C below the normal temperature. Plants kept at a temperature 9°C lower than normal throughout developmental phases 1—10.1 failed to head.

Maris Huntsman also showed an interesting response to low temperature. This variety only responded to a temperature 3°C lower than normal if the treatment was continued over phases 5—8 or 5—10, or throughout phases 1—10.1. However, treatment in phases 5—10 had a significant effect: a delay of 15 days. There was no response to a temperature 6°C lower than normal either in developmental phases 1—2, 3—4 or 1—4. If the treatment was carried out in later phases the effect was greater, giving a delay of 2—15 days. In the early phases the effect of reducing the temperature by 9°C was hardly greater than that of a 6°C reduction, but the effect increased in phases 5—8 to such an extent that if the treatment was extended to include phases 5—10 the plants failed to head. There was no heading in variants treated throughout at temperatures 9°C lower than normal either.

It can be seen from the data that the early variety Sadovo 1 and the late variety Maris Huntsman respond poorly to smaller changes in temperature. A significant lengthening

Table 1

Number of days from planting to heading at temperatures 3, 6 and 9°C lower than the normal programme

Developmental phase	Sadovo 1			
	Length of treatment days	—3°C	—6°C	—9°C
1—2	18	55	55	57
3—4	6	53	54	55
5—6	17	55	55	59
7—8	8	52	54	58
9—10	10	56	57	57
1—4	25	54	55	62
5—8	25	56	59	65
5—10	32	57	61	71
1—10.1	70	62	66	*
Control (normal temperature 1—10.1)			53	

Developmental phase	Bezostaya 1			
	Length of treatment days	—3°C	—6°C	—9°C
1—2	18	59	56	68
3—4	8	58	60	65
5—6	22	64	65	70
7—8	11	65	66	66
9—10	11	63	66	67
1—4	25	58	63	69
5—8	30	67	67	72
5—10	44	69	71	89
1—10.1	85	68	90	*
Control (normal temperature 1—10.1)			57	

Developmental phase	Maris Huntsman			
	Length of treatment days	—3°C	—6°C	—9°C
1—2	17	71	69	71
3—4	6	70	69	72
5—6	27	71	73	73
7—8	9	70	70	73
9—10	12	69	73	74
1—4	25	71	69	72
5—8	44	74	79	95
5—10	52	83	83	*
1—10.1	88	84	92	*
Control (normal temperature 1—10.1)			68	

* Did not head

of the vegetation period can be achieved in these varieties by carrying out the treatment in the later phases of vegetative growth at a temperature considerably lower (at least 9°C lower) than the normal programme. Bezostaya 1 proved to be more sensitive to temperature than the other two varieties, so its vegetation period can easily be regulated by temperature treatment. The development of Sadovo 1 could only be delayed sufficiently for it to flower at the same time as Maris Huntsman if it was treated in developmental phases 5—10 at a temperature 9°C below that of the normal programme. For Bezostaya 1 there were several treatments which served this purpose.

The treatments had a greater effect on the development of the varieties if they were continued over four phases of development. Thus, these treatments are analysed in Figs 1 and 2.

The effect of treatments applied in developmental phases 1—4 (Fig. 1) proved to be linear for all three varieties. The effect was strongest for Bezostaya 1, which shows the sensitivity of this variety. Their value is also greatest for Bezostaya 1: 0.962. In developmental phases 1—4 there are no treatments which produce nicking in the flowering times of early and late varieties, but the midseason variety Bezostaya 1 can be made to flower at the same time as the early variety Sadovo 1.

The effect of treatments applied in developmental phases 5—8 (Fig. 2) is also linear, with a close correlation for each variety. The wheat varieties responded more intensely to

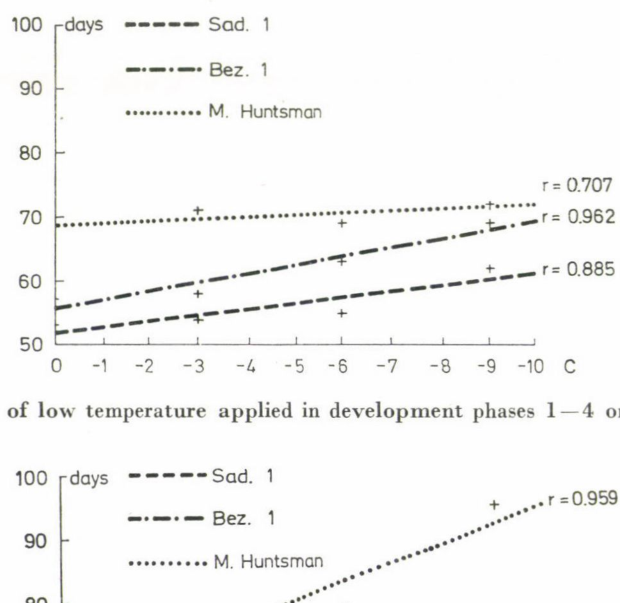

Fig. 1. Effect of low temperature applied in development phases 1—4 on heading date

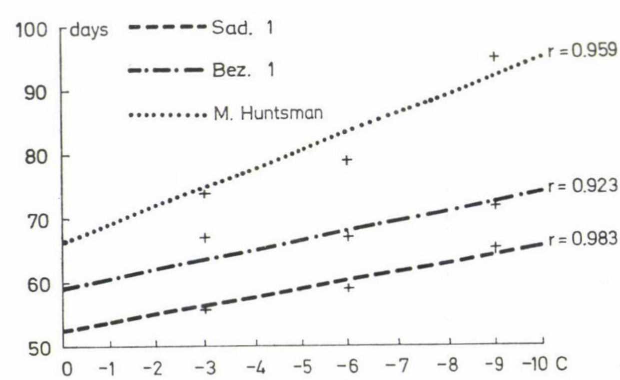

Fig. 2. Effect of low temperature applied in development phases 5—8 on heading date

Table 2

Effect of temperature treatment in different stages of development on heading in wheat

Treatment in phases	Effect of a 1°C change in temperature in days		
	Sadovo 1	Bezostaya 1	Maris Huntsman
1–2	0.40	1.00	0.23
3–4	0.23	0.87	0.37
5–6	0.60	1.33	0.57
7–8	0.57	0.93	0.50
9–10	0.43	1.10	0.73
1–4	0.93	1.37	0.33
5–8	1.30	1.50	2.87

treatment at this stage of development than in phases 1—4. The strongest response was that of Maris Huntsman. It could be established that if the development of wheat varieties is to be regulated by changing the temperature, the treatment is best carried out in developmental phases 5—8. The treatment needed to achieve nicking in the flowering times can be selected by drawing an imaginary line parallel to the horizontal axis in Fig. 2 and determining where this line intersects the regression lines of the individual varieties. The mutual flowering time can then be read from the vertical axis. In Fig. 2 it is impossible to draw a line which intersects both Maris Huntsman and Sadovo 1, whereas Bezostaya 1 can be made to flower at the same time as either of them. For instance, if Bezostaya 1 is grown on a normal programme, while Sadovo 1 is raised at a temperature 7°C lower than normal, they will both flower on the 58th day. Nicking in the flowering date could also be achieved by growing Bezostaya 1 at 3°C and Sadovo 1 at 9°C below the normal temperature.

On the basis of the developmental phases and the regression values the effectiveness of the treatment, in other words, how sensitive the wheat is to treatment in various phases of development, can be determined even more precisely. This sensitivity is expressed quantitatively by the data in Table 2, which give further confirmation of the above. The data show that treatment in developmental phases 5—8 produces the strongest effect. If the temperature is altered by 1°C during this period there will be a shift in the heading date of 1.3 days for Sadovo 1, 1.5 days for Bezostaya 1 and 2.87 days for Maris Huntsman. For Bezostaya, however, various treatments produced changes of more than 1 day, thus indicating the greater temperature sensitivity of this variety (Table 2).

It can thus be seen that the wheat vegetation period can be influenced by changing the temperature. The treatment can be continued as long as it does not have an adverse effect on grain yield. In the case of extreme treatments, nicking in the flowering times may be achieved, but this may be associated with poor seed setting.

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Prepared at the Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvásár.

L. Balla

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BENDING EFFECT OF SECTORIAL DOUBLE PRUNING ON FRUIT-TREES

When the position in space of perpendicular or nearly perpendicular shoots of fruit-trees is changed, the growth energy of the given shoot formation is more favourably distributed among several buds, whereby a greater number of buds will sprout out along the

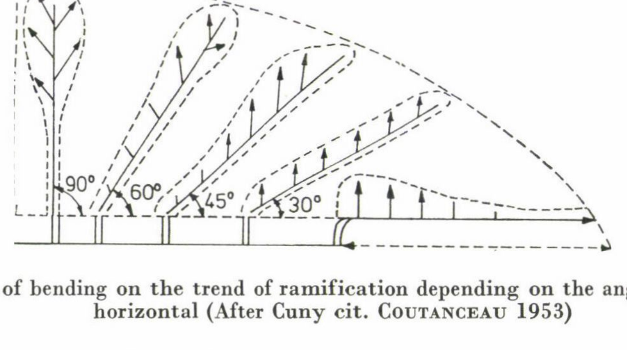

Fig. 1. **Effect of bending on the trend of ramification depending on the angle made with the horizontal (After Cuny cit. COUTANCEAU 1953)**

Fig. 2. Branching system of a cherry shoot after pruning to upper (inner) bud. (Photo Migend)

Fig. 3. Branching system of a cherry shoot after traditional pruning, i.e. to lower (outer) bud. (Photo Migend)

Fig. 4. Shoot shown in Fig. 2 after the removal of the terminal shoot. (Photo Migend)

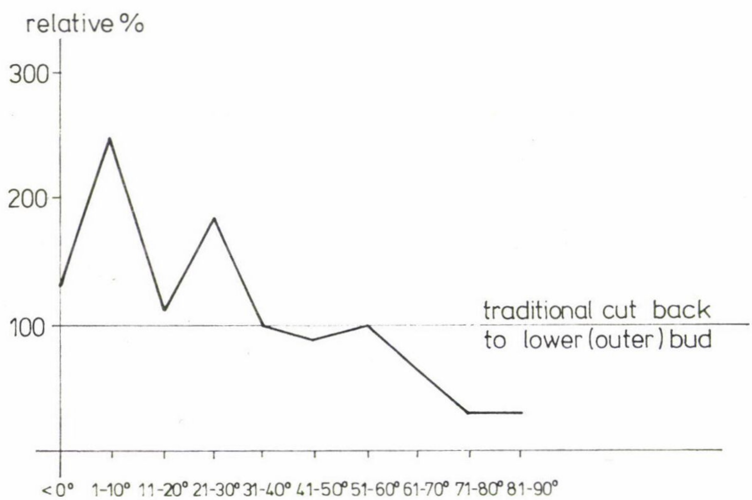

Fig. 5. Frequency of shoot angles as a percentage relative to the control, as a result of sectorial double pruning in Germersdorf cherry trees

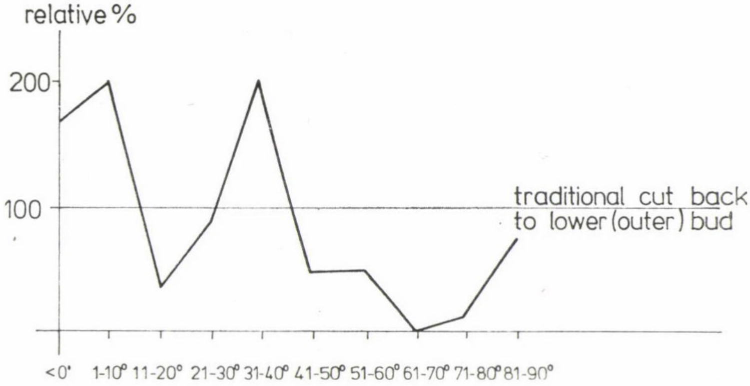

Fig. 6. **Frequency of shoot angles as a percentage relative to the control, as a result of sectorial double pruning in Érdi bőtermő sour cherry trees**

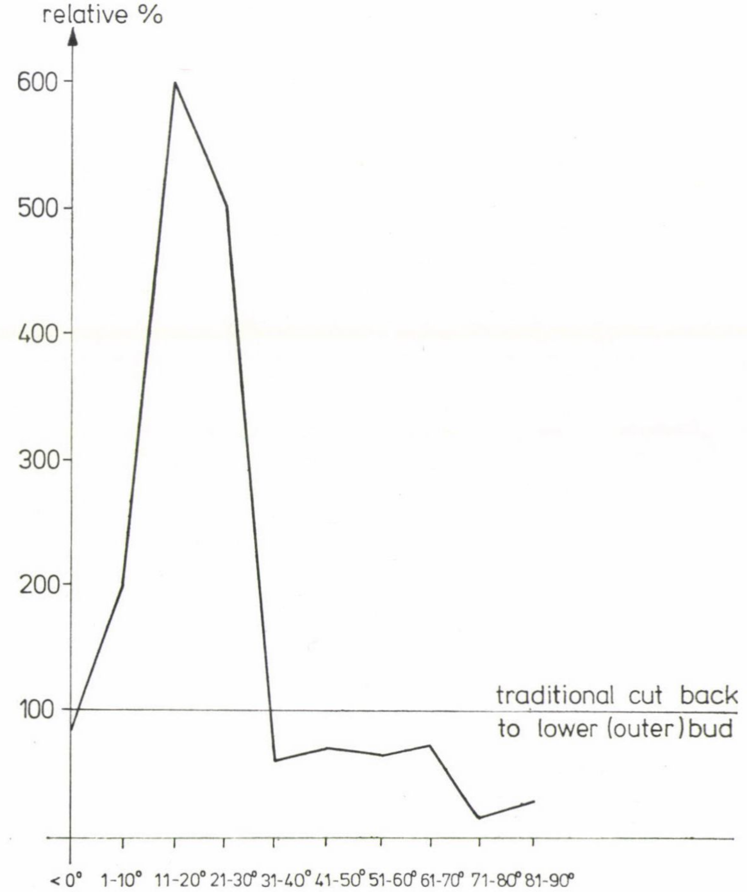

Fig. 7. **Frequency of shoot angles as a percentage relative to the control, as a result of sectorial double pruning in Hungarian apricot trees**

Table 1

Effect of sectorial double pruning on the system of branching in Germersdorf

Fruit species (variety)	Length of 2-year old part cut back tradi-tional	sec-torial	LSD	Shoots developing on the lower surface of the 2-year old part pruned: traditional No.	rel.%	sectorial No.	rel.%	LSD 5%	1%	0.1%
	pruning, cm			No.	rel.%	No.	rel.%	5%	1%	0.1%
Germersdorf cherry	42.7	43.7	—	0.2	100	1.4	700	0.45	0.62	0.85
Érdi bőtermő sour cherry	37.5	34.6	—	0.7	100	1.4	187	0.42	0.58	0.80
Hungarian apricot	49.9	46.3	—	0.6	100	1.3	217	0.64	0.88	1.22
	cm	cm		cm	rel.%	cm	rel.%	5%	1%	0.1%
Germersdorf cherry	42.7	43.7	—	11.4	100	85.4	749	34.9	48.3	66.7
Érdi bőtermő sour cherry	37.5	34.6	—	36.0	100	65.8	183	22.3	30.9	42.6
Hungarian apricot	49.9	46.3	—	25.7	100	72.1	280	31.1	43.1	59.5

Note: number of replications = 16

shoot axis. The new shoots and ramifications thus formed are weaker and their tendency to produce fruit is greater. At the same time, as seen in Fig. 1 bending alone, with no pruning, ensures the development of the shoot without its lower part becoming bare.

Sectorial double pruning considerably reduces the amount of manual work and the size of the support system required for bending. This is made possible by the action mechanism of the new pruning method. When a slanting shoot is pruned to an upper (inner) bud, the sectorial material transport disorder (unilateral nutrient transport disorder) caused by pruning occurs on the lower side of the shoot and eliminates the dominance of the terminal shoot. This transport disorder on the lower side of the pruned shoot is induced by a unilateral drying up which starts from the pruning wound. In this way favourably inclined shoots develop on the lower side, and the water-shoot formation is eliminated on the upper side (Fig. 2). This method thus has an effect opposite to that of the traditional method of pruning to a lower (outer) bud (Fig. 3). As a second phase of the sectorial double pruning, later, towards the end of the vegetation period, or in the dormant state, the terminal shoot is removed (Fig. 4). Then, in the following year the uppermost of the favourably positioned shoots (or several of them if necessary) will be pruned to an upper (inner) bud, and the "bending" of the shoots will be continued.

The effect above described has been confirmed by a series of experiments carried out for several years (Brunner 1972, 1976, 1978). Surveys made in 1978, for example, showed that seven times as many shoots were produced by sectorial double pruning on the lower side of the branch in Germersdorf cherry and twice as many in Érdi bőtermő sour cherry and Hungarian apricot trees than were obtained by traditional pruning. The total shoot production (cm) showed a similar trend. On the upper side of the branch, on the other hand, considerably fewer unfavourable water-shoot formations developed as a result of the new method of pruning (Table 1).

The "bending" effect of the sectorial double pruning method is clearly shown in Figs 5—7. In the case of shoots ranging from below the horizontal to those making an angle of *cherry, Érdi bőtermő sour cherry and Hungarian apricot trees*

Shoots developing on the upper surface of the 2-year old part cut back							Shoots developing on the lateral surface of the 2-year old part cut back						
traditional		sectorial		LSD			traditional		sectorial		LSD		
No.	rel.%	No.	rel.%	5%	1%	0.1%	No.	rel.%	No.	rel.%	5%	1%	0.1%
1.0	100	0.3	30	0.45	0.62	0.85	2.0	100	1.1	55	0.51	0.71	0.98
1.8	100	0.6	33	0.50	0.77	1.06	2.4	100	2.2	92	1.06	1.46	2.02
2.1	100	0.7	33	0.58	0.80	1.10	1.6	100	1.6	100	—	—	—
cm	rel.%	cm	rel.%	5%	1%	0.1%	cm	rel.%	cm	rel.%	5%	1%	0.1%
70.6	100	17.2	24	30.5—	42.2	58.3	97.7	100	67.0	69	36.6	50.7	70.0
113.9	100	30.1	26	31.4	43.4	59.9	126.7	100	98.0	77	—	—	—
142.4	100	34.5	24	67.9	94.0	129.7	93.9	100	83.2	89	—	—	—

30° with the horizontal the new method of pruning produced a significantly larger number of shoots in Germersdorf cherry trees compared to the control, while sharply reducing the number of shoots forming an angle of 60° with the horizontal. In this way the number and size of the pruning wounds will be indirectly reduced, since the unfavourably positioned shoots that have to be removed will be fewer. The sour cherry Érdi bőtermő gave a similar response. As to the Hungarian apricot, it is worth emphasizing that in addition to the above mentioned advantages, under the influence of the new pruning method the number of shoots making an angle of 20—30° with the horizontal increased five- to sixfold compared to the control. Sectorial double pruning is also able to produce the same results with pomiferous trees as it does with stone fruits (Brunner—Vizer 1977).

Thus, with a single annual pruning followed by a second pruning to remove the terminal shoot the new pruning method is able to "bend" a number of shoots to a favourable position without any supporting system and without tying down. Tying only becomes necessary at most in the first year if no suitable slanting shoots are available for pruning to an upper (inner) bud.

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Prepared at the Research Institute of Fruit Growing and Ornamentals (formerly Horticultural Research Institute), Budapest.

T. Brunner

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SINGLE FACTOR AND MULTIFACTORIAL ANALYSIS OF ADAPTABILITY IN WINTER WHEAT

Adaptation in plants develops as a result of a number of properties becoming simultaneously or successively effective. Its complex nature is a logical consequence of the multitude of effects occurring in the environment. This complexity is reflected in biometric methods. In the case of single factor analyses a joint evaluation of two or three parameters is often necessary in order to obtain information about the adaptability of a genotype. The widely used model devised by Eberhart—Russel (1966) also takes three parameters into consideration in evaluating the character in question. If the calculations are carried out by differentiating the growing sites (Verma—Chahal 1978, Bedő—Balla 1977), the number of sets of parameters will multiply according to the number of environmental groups. To simplify the Eberhart—Russel model Pfahler—Linskens (1979) carried out the $\log_{10}$ transformation of basic data before regression analysis by eliminating the third parameter (deviation from regression), thus maximizing the linear character of the regression. Besides the regression method various types of single factor analysis, including Wricke's ecovalence model (Wricke 1962) and Hanson's method (Hanson 1970) have been widely used to measure adaptability in genotypes.

Of the multifactorial analysis methods, Okuno *et al.* (1971) applied principal component analysis to the determination of interaction between variety and environment. Perkins (1972) employed the same method in comparing various *Nicotiana rustica* strains for adaptability. Suzuki—Kikuchi (1975) used the stepwise method of multifactorial regression analysis to study the effects of 8 climatic factors on the productivity of varieties. Abou-El-Fittouh *et al.* (1969) were the first to apply cluster analysis; they placed the different environments in clusters on the basis of a number of data.

In the course of the present investigations efforts were made to discover how to evaluate the adaptability of a given variety by single factor and multifactorial methods taking two characters (productivity and flowering time) into consideration.

A changing environment is a basic criterion in studying adaptability, so the productivity and flowering time data of the 8th IWWPN (International Winter Wheat Performance Nursery) were used in the calculations, taking into consideration the 30 experimental sites from where both data were available. Among the 16 varieties examined there were early, medium late and late winter wheats. (Lerma Rojo 64 was the only spring variety.) These varieties came from different countries and had, accordingly, different daylength reactions.

The flowering time was expressed by the number of days from 1st January.

Productivity and flowering time were examined for stability using three methods.

1. The Eberhart—Russel model, which was modified to the extent that the regression error used as the third parameter included the totalled error. The calculations were thus made using the following formula:

$$s^2_{d_i} = \sum (Y_{ij} - Y_{ij})^2/n - 2$$

2. Wricke's ecovalence method.

Table 1

Production stability of the varieties examined on the average of all the growing sites, and at sites with yields higher or lower than average
(Eberhart—Russel model)

Variety	Total sites			Lower than average			Higher than average		
	$\bar{x}$	b_i	$s^2_{b_i}$	$\bar{x}$	b_i	$s^2_{b_i}$	$\bar{x}$	b_i	$s^2_{b_i}$
1. Talent	49.0	1.23	74.2	30.3	1.29	104.5	63.9	0.96	162.2
2. Martonvásári 2	47.2	1.02	36.8	31.7	0.93	61.6	59.5	0.96	63.4
3. Bezostaya 1	46.5	1.00	32.9	32.3	0.88	62.6	57.9	0.98	38.8
4. Blueboy	46.4	0.98	44.9	32.7	0.98	64.1	57.2	1.12	48.6
5. GK Fertődi 2	46.2	1.06	48.5	30.8	0.98	25.5	58.4	1.11	58.4
6. Biserka	44.7	1.18	68.7	26.3	1.05	70.5	59.2	1.01	89.0
7. Maris Huntsman	44.6	1.07	155.4	28.9	1.17	208.1	57.0	0.95	113.4
8. Dunav 1	43.5	1.06	43.7	27.8	1.00	30.9	55.9	0.92	53.6
9. Kormoran	43.4	1.00	87.6	27.9	0.97	106.5	55.6	0.91	66.5
10. Kitakomi Komugi	42.7	1.10	54.2	26.3	1.03	30.6	55.7	1.09	78.0
11. Maris Templar	42.5	1.07	140.2	27.3	1.26	164.4	54.5	0.93	101.6
12. Lely	42.3	0.93	140.7	28.1	0.94	145.1	53.5	0.78	98.9
13. Sentinel	42.0	0.95	55.0	28.5	0.87	34.5	52.8	1.07	65.6
14. TRS 237	39.8	0.96	32.4	26.1	0.92	17.2	50.7	1.04	45.4
15. Atlas 66	35.4	0.96	36.7	21.3	0.97	73.2	46.7	0.91	82.9
16. Lerma Rojo 64	30.3	1.04	243.8	16.8	1.04	274.2	41.0	1.39	437.1

3. A synthesis of Wricke's ecovalence model with principal component analysis. First the ecovalence values (z_{ij}) of the varieties at each growing site were determined according to the formula below:

$$z_{ij} = x_{ij} - \frac{x_{i.}}{q} - \frac{x_{.j}}{p} + \frac{x_{..}}{pq}$$

A matrix was formed from the ecovalence values of all the varieties at all the growing sites and was evaluated using principal component analysis (Cattel 1965). The first two principal component values obtained were plotted and the varieties examined were grouped accordingly.

The stability of productivity calculated by the Eberhart—Russel model was checked not only by an analysis on the average of all the growing sites, but also by the differentiation of sites with yield averages lower or higher than the general mean.

The measurement of adaptability on the basis of productivity. According to the Eberhart—Russel method (Table 1), the varieties Martonvásári 2, Bezostaya 1 and Blueboy had high productivity on the average of all the experimental sites and could be classified as generally well adaptable types, as they had regression coefficients close to 1 and small regression errors. Talent and Biserka are varieties which have specific adaptation. The analysis made by dif-

Table 2

Stability of productivity for the varieties examined on the basis of Wricke's ecovalence value

Variety	Ecovalence value
Lerma Rojo 64	16.52
Biserka	7.54
Kitakomi Komugi	8.52
Dunav 1	5.93
GK Fertődi 2	5.03
TRS 237	6.11
Talent	8.81
Martonvásári 2	5.86
Bezostaya 1	4.71
Sentinel	7.99
Blueboy	7.20
Atlas 66	7.34
Maris Huntsman	9.31
Kormoran	7.30
Maris Templar	9.52
Lely	9.78

ferentiating the growing sites shows that at experimental sites with average yields lower than the general mean Bezostaya 1, Martonvásári 2 and Blueboy were stable varieties with good adaptability, while even varieties showing specific adaptation (Talent, Biserka, Maris Huntsman and Maris Templar) did not produce as much as the well adapted ones. At sites with average yields higher than the general mean Blueboy and GK Fertődi 2 showed the highest plasticity. According to the interpretation of Verma—Chahal (1978) under intensive cultivation conditions varieties of the latter type show the highest degree of adaptability. However, in the present experiments, Martonvásári 2 and Biserka, varieties with average plasticity and stable reactions, proved to have higher productivity and showed a greater regression error; Maris Huntsman and Maris Templar displayed similar behaviour though they produced less.

Wricke's ecovalence analysis reveals that the greatest deviation from the average yield at the different experimental sites was obtained with the spring wheat Lerma Rojo 64 (Table 2). With the Eberhart—Russel method this large difference was expressed primarily by the above-average regression error. Comparing the ecovalence values of the other varieties it is found that they are higher in late, and lower in medium early and some early varieties. The late varieties include Lely, Maris Huntsman and Maris Templar, while the medium early and early varieties are Bezostaya 1, Martonvásári 2, Dunav 1, TRS 237 and GK Fertődi 2.

By plotting the values of the first and second principal components calculated from the ecovalence data (Fig. 1) several groups of varieties were obtained. In the first quarter (++) Kitakomi Komugi and TRS 237 were closest to one another, while GK Fertődi 2 and

Lerma Rojo 64 occupied relatively separate places. In the second quarter (+ —) Martonvásári 2, Bezostaya 1, Sentinel and Blueboy form a single group. A similarly close unit is formed in the third quarter (— —) by the four West European varieties, Kormoran, Maris Huntsman, Maris Templar and Lely. In the fourth quarter (— +) the two Yugoslav varieties Biserka and Dunav 1, and in part the variety Talent are close to one another, while Atlas 66 is placed separately.

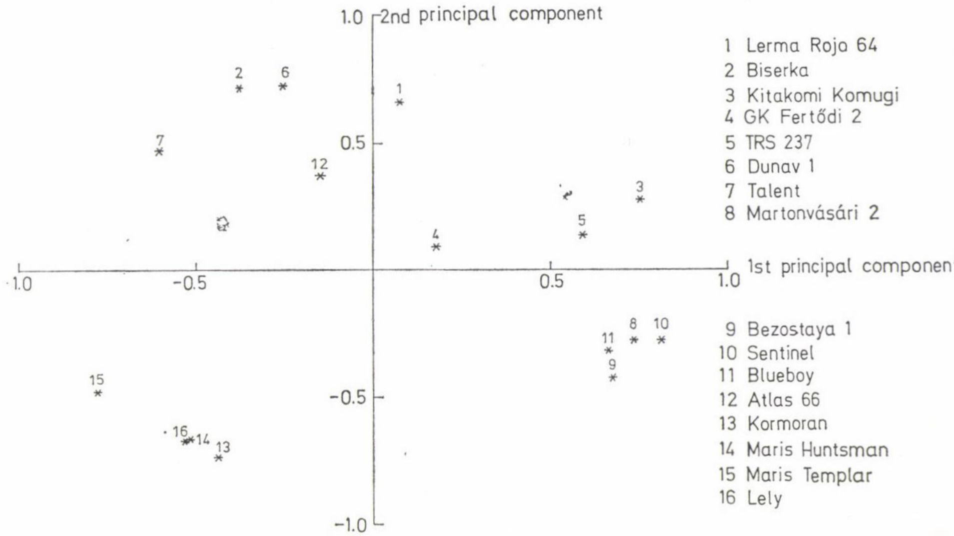

Fig. 1. **Principal component analysis of productivity (1st and 2nd principal components)**

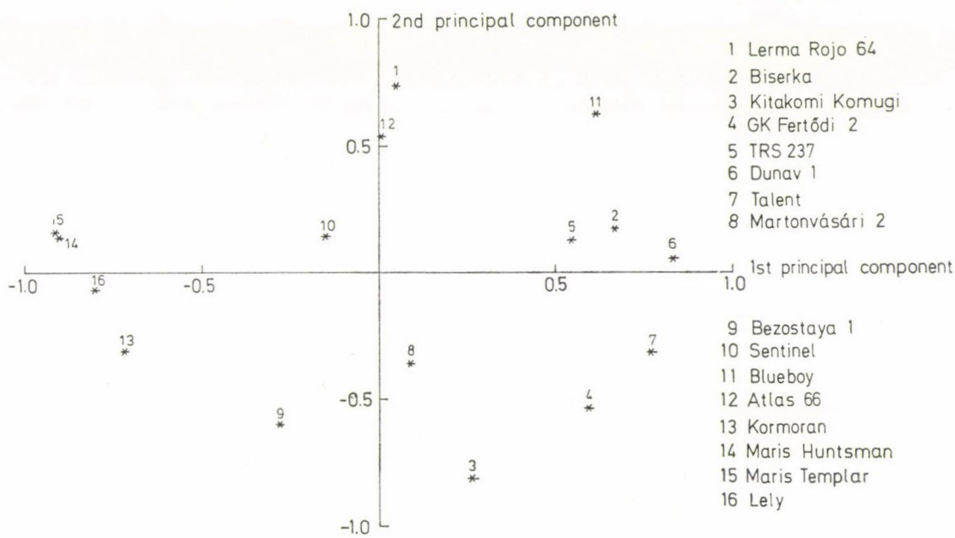

Fig. 2. **Principal component analysis of flowering time (1st and 2nd principal components)**

The measurement of adaptability on the basis of flowering time. The regression coefficients did not help in differentiating the varieties (Table 3), though the regression error is less for early and medium early varieties than for late ones.

Wricke's ecovalence also increased from the early to the late varieties (Table 4). The latter values are two or more times as great as the values for the early varieties. The only exception is the spring wheat Lerma Rojo 64. In Fig. 2, which was constructed on the basis of the first two principal components obtained from the ecovalence values, most of the early and medium early varieties are found in the right-hand quarters, while in the (−+) quarter, i.e. to the left of the origo, Maris Huntsman, Maris Templar and Lely form a group, while Kormoran is placed at a slight distance from them. Early and medium early varieties, with the exception of 3 varieties, are almost in line. This difference developed on the basis of the values of the second principal component.

To sum up, it can be seen that in analysing the two characteristics it was only on the basis of productivity that the Eberhart—Russel model gave adequate information about the adaptability of the varieties examined, while when evaluating the time of flowering the varieties could only be differentiated on the basis of s^2_{di}. With a view to simplifying the method calculations were made by transforming the basic data ($\log_{10}$, $1/\log_{10}$, etc.) and carrying out regression analysis on the data thus obtained. Although the regression error was reduced, at the same time the value of the correlation coefficient became lower compared to the original values. It is thus likely that in this case, owing to the large number of data series ($n = 30$), regression analysis on the original yield data is the most reliable. In their $\log_{10}$ transformation

Table 3

Stability of flowering time for the varieties examined according to the Eberhart—Russel model

Variety	$\bar{x}$	b_i	$s^2_{b_i}$
Lerma Rojo 64	152.5	1.06	82.8
Biserka	155.1	1.03	14.0
Kitakomi Komugi	156.3	10.3	9.8
Dunav 1	156.3	1.02	7.6
GK Fertődi 2	156.8	1.03	9.6
TRS 237	157.2	1.02	9.6
Talent	160.0	1.01	5.9
Martonvásári 2	160.1	1.01	4.8
Bezostaya 1	160.3	0.99	8.6
Sentinel	161.0	1.00	7.3
Blueboy	161.3	1.03	12.0
Atlas 66	161.7	1.00	7.4
Maris Huntsman	169.6	0.93	39.5
Kormoran	170.2	0.93	44.9
Maris Templar	170.5	0.92	55.0
Lely	172.6	0.91	70.0

Table 4

Stability of flowering time for the varieties examined according to Wricke's ecovalence value

Variety	Ecovalence value
Lerma Rojo 64	7.66
Biserka	3.04
Kitakomi Komugi	2.29
Dunav 1	2.36
GK Fertődi 2	2.34
TRS 237	2.67
Talent	2.25
Martonvásári 2	2.02
Bezostaya 1	2.86
Sentinel	2.65
Blueboy	2.71
Atlas 66	2.67
Maris Huntsman	4.06
Kormoran	4.72
Maris Templar	5.04
Lely	5.65

Pfahler—Linskens (1979) used 8 basic data; this is presumably the reason why this solution proved better. The matrix formed from Wricke's ecovalence values was suitable for classifying the varieties by principal component analysis in the case of both productivity and flowering time; at the same time, Wricke's method alone does not indicate the adaptability as clearly as the Eberhart—Russel model does. In fact, the principal component values were previously calculated from the matrix of the yield data, though this led to the separation of Lerma Rojo 64 from the 15 winter wheat varieties. However, in earlier investigations a close agreement was found between the Eberhart—Russel model and the analysis of components calculated from the ecovalence matrix (Bedő 1979), where, on the basis of values concentrated in a single component, varieties with good general adaptability fell within the positive range, and those with specific adaptation in the negative range. Nevertheless principal component analysis provides a more detailed picture of the variety groups. This possibility can best be exploited in breeding in such a way that the adaptability types of new lines can be determined alongside standards with characteristic adaptibility. Such knowledge may provide useful information in subsequent crossing as well as in determining the most suitable growing area for the given genotype. Thus the introduction of certain specially adapted types into commercial production need not be abandoned, though they are recommended for production only in the proper environment.

On the basis of the present studies it can also be stated that productivity, as a polygenic character, is a better indication of the adaptability of a variety than the time of flowering.

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Prepared at the Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvásár.

Z. BEDŐ, L. BALLA, A. ÁBRÁNYI, L. SZUNICS

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POSSIBILITIES OF POLLINATING SINGLE VARIETY APPLE ORCHARDS WITH MALUS SPECIES

Large yields coupled with low investments and high quality are preconditions for economical apple growing. The commercial apple varieties grown in Hungary are self-sterile, so fruit setting ensuring a large yield can only be attained with the joint plantation of several varieties satisfying all the criteria for favourable pollination. However, with regard to the necessary cultural practices, particularly pruning, plant protection and harvesting, there are considerable differences between the varieties. When several varieties are planted together there is little or no opportunity of taking these differences into consideration, i.e. of applying agrotechnics specific to the variety. The use of *Malus* species as pollinators renders it possible to establish pure-bred single variety apple orchards, which are technologically and economically more advantageous.

On the basis of favourable foreign experience (WILLIAMS 1975, 1977, JONKERS *et al.* 1978), work was begun in 1977 to develop a variety-specific agrotechnology using *Malus* species at the Departments of Fruit Growing and Botany of the University of Horticulture, Budapest. The research, planned to cover several years, is aimed at establishing the possibilities and conditions of using *Malus* species and varieties as pollinators, selecting the taxa best suited to the commercial apple varieties (Jonathan, Starking, Golden Delicious), and elaborating technological models for farm purposes.

In 1977 and 1978, the first two years of the research programme, the flowering biology of *Malus* species (time, duration and dynamics of flowering, flowering time groups, simultaneous flowering with commercial varieties), their fruit setting characteristics (natural self-fertility, fruit setting of open pollinated flowers, capacity for pollen germination, and pollen tube formation, fertilizing ability on Jonathan, Starking and Golden Delicious) and the growth habits of the trees were studied.

From the rich *Malus* collection found in the Botanical Garden of the University of Horticulture at Soroksár, 19 species and varieties were chosen, each marked with a code number (e.g. SBK-3), and these were examined for flowering phenology, self-fertility and outcrossing. The pollen collected here was studied for physiological properties and fertilizing ability (artificial pollination with the *Malus* species chosen) at the Helvécia Station of the National Institute for Agricultural Variety Testing.

For the flowering phenology observations an average of 150—250 flower buds per tree were designated, in zones of identical flower density at medium height. Two stages of flowering (opening and deflorescence) were evaluated every day during the same part of the day. From the data of flowering dynamics phenograms were constructed, and the flowering time group of each species and the extent of simultaneous flowering with the commercial apple varieties were determined.

Fertilizing ability was evaluated as displayed on the three most important commercial apple varieties: Jonathan, Starking and Golden Delicious. Flowers artificially pollinated with *Malus* species were isolated in parchment bags, and fruit setting was evaluated on three occasions: after the cleaning fruit fall (I in Table 3), following the fruit fall in June (II) and before harvest (III).

There was a very great difference between the two years in the weather conditions prevailing during the periods of observation. The growth season of 1977 was warmer than average, dry and very sunny, while in 1978 the weather was unusually cool and rainy.

Taking the duration of flowering, the time of mass flowering and the flowering phenograms into consideration the *Malus* species and varieties can be placed in flowering time groups as seen in Table 1. The groups include only those species and varieties which had stable flowering periods in both years. The *Malus* species belonging to the medium late flowering time group showed the closest synchronization with the varieties Jonathan and Starking as regards

Table 1

Flowering time groups of Malus species and varieties
(Soroksár, 1977—1978)

Very early flowering		Medium early flowering		Medium late flowering		Very late flowering	
Code number	Name	Code number	Name	Code number	Name	Code number	Name
SBK-1	*M. floribunda* var. *atropurpurea*	SBK-6	*M. spectabilis*	SBK-5	*M. baccata*	SBK-4 X	*Sorbomalus*
SBK-9	*M. floribunda* var. *atropurpurea*	SBK-7	*M. baccata*	SBK-8	*M. baccata*		
		SBK-336	*M. pumila*	SBK-1003	*M. domestica-pumila*		
				SBK-1014	*M. dasyphylla-pumila*		
				Jonathan (control)			
				Starking (control)			
				Golden Delicious (control)			

Table 2

Malus species and varieties flowering simultaneously with the varieties Jonathan and Starking
(Soroksár, 1978)

Malus species or variety		Extent of simultaneous flowering (%) with	
Code number	Name	Jonathan	Starking
SBK-5	*M. baccata*	70—100	30— 50
SBK-8	*M. baccata*	30— 70	70—100
SBK-1003	*M. domestica-pumila*	70—100	30— 70
SBK-1014	*M. dasyphylla-pumila*	70—100	50— 70

flowering. Species with medium early flowering times only ensure adequate overlapping in years when flowering proceeds rapidly. Because of their earlier flowering, these species may be of importance mainly in attracting bees to the orchard.

The extent of simultaneous flowering with the varieties Jonathan and Starking varies according to the species (Table 2). With a view to reliable overlapping, at least two species or varieties showing a minimum of 50% simultaneous flowering with the commercial varieties must be include in the pollination system.

The fertilizing ability of *Malus* species belonging to the same flowering time group as the commercial varieties is presented in Table 3. As a control, the results of artificial pollination with the other two varieties (e.g. Jonathan ♀ with Starking and Golden Delicious ♂) and the results of fruit setting after open pollination are shown in the Table. To evaluate the fertilizing ability, fruit setting and the number of seeds per fruit must both be taken into consideration.

The fruit setting required to obtain large yields is a function of flower density, among others things. In Hungary, in the case of the three major commercial varieties of apple (Jonathan, Starking and Golden Delicious), a 5—10% fruit setting depending on the flower density can be regarded as an adequate yield basis. Fruit setting is in close relationship with the weather conditions. In the present experiments the results of fruit setting were generally worse in 1978. Among the varieties, Starking (♀) showed the lowest degree of fertility.

Among the *Malus* species which flowered at a different time from the commercial varieties, there were also some with outstanding fertilizing ability [e.g. *M. floribunda* and *M. spectabilis* in the case of Jonathan (♀), *M. halliana* and *M. floribunda* var. *atropurpurea* in the case of Starking (♀), and certain varieties of *M. floribunda* and *M. pumila* in the case of Golden Delicious (♀)]. These may be of importance under changed ecological and technological conditions (e.g. when grafted onto various rootstocks or onto trees of the commercial varieties), provided there is adequate overlapping of flowering time, or when using artificial pollination.

While exploring the possibilities of artificial pollination, pollen mixtures were also used on the varieties Jonathan and Golden Delicious in 1978 and some very interesting results were obtained. In the case of Jonathan (♀), the SBK-336 + Golden Delicious pollen mixture (33% fruit setting at harvesting time) is worth mentioning, as is the SBK-336 + Starking pollen mixture (30.8% fruit setting) for the variety Golden Delicious.

In Table 4 suggestions are made as to the proportions of commercial varieties and *Malus* species which should be used as pollen donors. Under Hungarian conditions the varieties

Table 3

Effect of pollen donor Malus species and varieties on fruit setting and seed yield in the apple varieties Jonathan, Starking and Golden Delicious
(Helvécia, 1977–1978)

Name of variety (♀)	Code number of *Malus* species (♂)	Number of pollinated flowers		Fruit setting (%)						Number of seed per fruit			
				1977			1978			1977		1978	
		1977	1978	I.	II.	III.	I.	II.	III.	full	empty	full	empty
Jonathan	SBK-1003	144	261	66.7	41.7	34.7	69.0	8.0	6.9	5.2	0.4	6.8	2.4
	SBK-1014	152	240	36.8	21.0	17.1	73.7	23.7	15.8	5.3	0.5	7.1	1.9
	SBK-5	174	231	36.8	9.2	8.0	53.2	7.8	6.5	3.2	0.7	3.5	0.0
	SBK-8	—	258	—	—	—	53.5	5.8	5.4	—	—	6.0	2.7
	Starking	98	195	76.0	23.1	17.0	81.5	27.7	20.5	4.5	1.0	6.8	1.5
	Golden Delicious	101	210	89.0	39.0	22.0	65.7	27.1	17.1	5.1	0.9	7.2	1.4
Starking	SBK-1014	112	—	31.2	28.6	18.7	—	—	—	5.3	1.2	—	—
	SBK-1003	182	—	25.0	17.7	13.5	—	—	—	6.3	1.0	—	—
	SBK-5	99	72	27.3	9.1	7.1	0.0	0.0	0.0	2.0	3.0	—	—
	Jonathan	95	120	41.0	28.4	25.3	20.8	7.7	5.8	6.5	1.0	5.9	1.2
	Golden Delicious	102	152	44.1	28.4	16.7	24.3	7.9	6.6	4.8	0.9	6.2	1.5
Golden Delicious	SBK-5	102	258	26.5	17.6	13.7	55.8	8.1	7.0	5.0	0.5	6.2	0.8
	SBK-1003	132	172	27.3	18.2	13.6	80.2	25.6	21.5	4.5	1.0	7.0	0.7
	SBK-1014	98	152	14.3	1.0	1.0	57.9	8.5	7.2	5.0	1.0	8.2	0.0
	SBK-8	—	158	—	—	—	65.8	8.2	7.6	—	—	6.0	1.0
	Starking	126	154	28.5	25.4	19.8	59.7	18.8	16.2	5.0	0.2	8.0	0.3
	Jonathan	140	185	77.1	30.0	27.1	50.2	11.3	9.1	7.9	0.8	7.5	2.0
Jonathan	Open pollination	962	588	22.4	21.6	19.9	47.2	13.9	8.8	6.5	0.8	6.4	0.5
Starking		968	605	5.8	5.0	4.1	14.7	6.8	4.6	4.4	0.5	5.6	1.4
Golden Delicious		740	809	19.5	11.1	5.9	36.7	10.5	8.3	7.5	0.5	5.2	1.8

Table 4

Suggested ratios of commercial varieties and Malus pollinators in the case of joint plantation with three Malus species

Method of cultivation	Spacing (m)	Fertility of the commercial variety		
		Low (less than 5% fruit setting)	Medium (5—10% fruit setting)	High (more than 10% fruit setting)
Spindle bush	7×4	1 : 5	1 : 7	1 : 9
Hedge	5×3	1 : 6	1 : 8	1 : 10
Slender spindle	3×1.4	1 : 7	1 : 9	1 : 11

Jonathan and Starking can be placed in the medium fertility group, while Golden Delicious belongs to the high fertility group. In the model presented, two of the three *Malus* species blossom at the same time as the commercial variety, while one of them flowers earlier. If only those *Malus* species which flower simultaneously with the commercial variety are used, the ratios can be increased by one (e.g. from 1 : 7 to 1 : 8, irrespective of the number of pollen donor *Malus* species).

The research cannot be regarded as complete; the final results will need several years of further investigation. Once these are available it will be possible to set up single variety commercial orchards where the cultural practices can be adjusted to the requirements of a single variety, which should mean that higher quality and larger yields will be attained with a lower cost investment. In addition, by using *Malus* species or varieties as supplementary pollinators the yield reliability can be increased even in orchards which have not produced the expected results so far, due to deficient pollination. With a view to putting this into effect as soon as possible, the plantation of the first farm-scale model orchards has already begun.

*

Prepared at the Department of Fruit Growing and Department of Botany of the University of Horticulture, Budapest, and at the Kecskemét College of the University of Horticulture.

J. Nyéki, M. Soltész, M. Tóth, F. Gyuró, A. Terpó

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COMBINING ABILITY STUDIED BY DIALLEL AND MULTIVARIATE ANALYSIS IN WHEAT VARIETIES

Reports of studies on combining ability in wheat varieties have recently been published by a number of Hungarian authors (RAJKI—RAJKI 1966, 1968, 1970, LELLEY 1967, 1976, SZUNICS 1967, 1970, BALLA 1971, BARABÁS *et al.* 1973). The diallel crossing method for studying combining ability in wheat has been employed by MATUZ *et al.* (1974), SZUNICS *et al.* (1975) and MATUZ (1976).

The present work was aimed at using diallel and multivariate analysis to study some quantitative characters important for wheat breeding in F_1 hybrids derived by crossing various wheat varieties.

The work was carried out at the Agricultural Research Institute of the Hungarian Academy of Sciences (Martonvásár). The varieties were crossed in 1976. The seed were sown on 27th October 1976 into soil cultivated as is usual in a garden, in a random block design with four replications. After a mixture of pea and sunflower as pre-crop 510 kg fertilizer containing nitrogen, phosphorus and potassium as active agents in a 1 : 1 : 1 ratio was distributed. The length of the plots was 1 m, the distance between the rows 10 cm, and the plant distance 5 cm. After harvesting, all the plants in the plots were processed.

Single factor analysis of variance was carried out to determine whether a significant difference could be found between the characters examined for the crossing partners and their hybrids. The heterosis effect (H) was calculated on the basis of the deviation from the agronomically better parent, which is called heterobeltiosis by FONSECA—PATTERSON (1968) and true heterosis by OMAROV (1975).

General and specific combining abilities were evaluated by the 1st method of model I in GRIFFING (1956). In this complete diallel crossing system the parents and all F_1 hybrids are included (p^2). The method was adapted for the computer using the works of KEULS—GARRETSEN (1977) and GARRETSEN—KEULS (1978), where crossing between the $\underline{i}$-th female and $\underline{j}$-th male parent (X_{ij}) is described by the following model:

$$X_{ij} = \mu + g_i + g_j + S_{ij} + \sigma_i + \varepsilon_j + r_{ij} + e_{ijk},$$

where μ is the general mean level, g_i the general combining ability of the $\underline{i}$-th parent, S_{ij} the specific combining ability of the cross between the $\underline{i}$-th and $\underline{j}$-th parents, σ_i and ε_j are the general reciprocal effects due to the $\underline{i}$-th female and $\underline{j}$-th male, respectively, and e_{ijk} is the error term of the $\underline{k}$-th replication.

A joint evaluation of the combining ability of the 9 properties studied in the experiment is only possible with multivariate analysis. The correlation matrix of the variants was determined. Having obtained a very close correlation principal component analysis was carried out on the variants. Thus, by transforming the original nine characters into artificial variants a lower number of principal components could be differentiated. The eigenvalue problem was solved by the iteration method described by KENDALL (1968) and AFIFI—AZEN (1972). In addition the distance measurable between the characters examined in the 3—9-dimensional Euclidean space was determined; from this, conclusions can be drawn on the closeness of the relationship. The n-dimensional distance between parameters $\underline{i}$ and $\underline{j}$ (d_{ij}) was computed according to the formula below:

$$(d_{ij}) = \sqrt{\sum_{k=1}^{n} [f(i, k) - f(j, k)]^2};$$

where f(i, k) is the $\underline{k}$-th principal component weight of the $\underline{i}$-th character.

Table 1

Data of parents

(Martonvásár,

Parents and hybrids	Grain weight/plot		Grain weight/plant		Grain weight/ main ear	
	g	H	g	H	g	H
Krasnodar 1	88.7		5.61		1.72	
Kavkaz	110.9		7.37		2.96	
Martonvásári 3	114.3		8.20		2.29	
Olesen	41.0		3.51		1.21	
Krasnodar 1 × Kavkaz	113.6	2.43	7.86	6.65	2.49	−15.88
× Martonvásári 3	116.5	1.92	8.96	9.27	2.36	3.06
× Olesen	104.9	18.26	9.09	62.03	2.02	17.44
Kavkaz × Krasnodar 1	89.7	−19.12	6.31	−14.38	2.67	− 9.80
× Martonvásári 3	123.9	8.40	7.98	− 2.68	2.33	−21.28
× Olesen	134.6	21.37	9.92	34.60	2.73	− 7.77
Martonvásári 3 × Krasnodar 1	90.0	−21.26	6.46	−21.22	1.98	−13.54
× Kavkaz	117.3	2.62	7.84	− 4.39	2.28	−22.97
× Olesen	115.6	1.14	7.71	− 5.98	2.24	− 2.18
Olesen × Krasnodar 1	99.1	11.72	7.61	35.65	1.90	10.47
× Kavkaz	88.5	−20.20	10.67	44.78	2.72	− 8.11
× Martonvásári 3	120.2	5.16	10.20	24.39	2.49	8.73
Mean	104.3		7.84		2.27	
$LSD_{5\%}$	36.2		2.51		0.35	
$LSD_{1\%}$	45.1		3.28		0.46	
$LSD_{0.1\%}$	53.8		4.27		0.60	

The principal component values for the varieties and F_1 hybrids were computed. After standardizing the basic matrix, the eigenvector matrix obtained in the principal component analysis was multiplied by the matrix of the standardized basic data (Sváb 1979). For the mathematical operations a Hewlett—Packard 9831 A type computer was used. Eight characters were evaluated by diallel analysis, and 9 by multivariate analysis.

In the present experiment the variety Martonvásári 3 produced the highest yield due to its high tillering capacity and thousand-grain-weight (Table 1). The yield and yield components of the variety Kavkaz are very good, but its straw is too long. Krasnodar 1 has poorer productivity but has short straw. According to Bessarab—Zhirov (1975) the latter variety has two recessive dwarfing genes. Under Hungarian conditions the variety Olesen gives a very low yield; its straw is short: dwarfness is determined by three dominant genes (Dorofeev 1976).

and F_1 hybrids

1976–1977)

1000-grain weight/ main ear		Spikelet number/ main ear		Grain number/ main ear		Length of main ear		Plant height	
g	H	n	H	n	H	cm	H	cm	H
34.2		20.2		50.4		9.14		66.2	
43.9		23.2		67.2		9.65		94.7	
45.2		20.1		50.8		8.89		89.3	
28.7		18.3		41.9		8.14		40.7	
41.8	– 4.78	21.7	– 6.47	59.6	–11.31	9.33	– 3.32	86.2	– 8.98
41.6	– 7.96	20.6	1.48	56.9	12.01	9.23	0.98	82.1	– 8.06
33.5	– 2.05	20.8	2.97	59.9	18.85	9.64	5.47	55.9	–15.56
42.6	– 2.96	21.9	– 5.60	62.5	– 6.99	9.50	– 1.56	86.5	– 8.66
45.3	0.22	20.7	–10.78	51.5	–23.36	8.61	–10.78	96.7	2.11
44.8	2.05	21.8	– 6.03	60.7	– 9.67	9.27	– 3.94	74.4	–21.44
40.7	– 9.96	19.9	– 1.49	48.7	– 4.13	8.73	– 4.49	81.8	– 8.40
45.9	1.55	21.2	– 8.62	49.7	–26.04	8.91	– 7.67	95.4	0.74
39.6	–12.39	20.0	– 0.50	56.5	11.22	9.41	5.85	72.6	–18.70
31.9	– 6.73	20.5	1.49	59.0	17.06	9.32	1.97	55.8	–15.71
43.6	– 0.68	21.3	– 8.19	62.3	– 7.29	9.35	– 3.11	72.7	–23.23
42.5	– 5.97	20.4	1.49	58.5	15.16	9.13	2.70	72.2	–19.15
40.4		20.7		56.0		9.13		67.3	
2.5		0.9		6.5		0.61		3.4	
3.3		1.1		8.7		0.82		4.5	
4.3		1.5		11.3		1.87		5.9	

Yield per unit area is the result of several components in interaction with one another. The largest yield, and also the highest heterosis effect (21.3%), was given by the combination Kavkaz × Olesen. The reciprocal cross was considerably poorer (Table 1). As regards grain weight per plant and grain weight per main ear the hybrid Krasnodar 1 × Olesen proved the best. On the basis of thousand-grain-weight per main ear and number of spikelets per main ear a negative heterosis effect was obtained in a considerable majority of the combinations examined. For grain number per main ear the negative deviation was generally larger than the positive one. The same can be said of the trend in ear length.

As seen from the table, the plant height in the varieties Kavkaz and Martonvásári 3 is more than twice that of the variety Olesen, and about one and a half times that of Krasnodar 1. In the tall × tall combinations a low positive heterosis effect was found. Olesen had the strongest dwarfing effect, followed by Krasnodar 1. The hybrids of dwarf × dwarf varieties had the shortest stalks, though the plants were taller than the shorter parent (Olesen 40.7 cm, Krasnodar 1 66.2 cm, Olesen × Krasnodar 1 55.8 cm, Krasnodar 1 × Olesen 55.9 cm). This character was thus manifested as an intermediate trait, but the effect of the "taller" parent was stronger. In the dwarf × tall combinations intermediate inheritance was observed.

In the eight characters examined no significant reciprocal effect was found in the F_1 hybrids. This statement only proved true at the 1% level for grain weight/main ear and grain number/main ear in Krasnodar 1 × Martonvásári 3 and Martonvásári 3 × Krasnodar 1, for grain weight/plot in Kavkaz × Olesen and its reciprocal, and for thousand-grain-weight/main ear in the case of Martonvásári 3 × Olesen and Olesen × Martonvásári 3 hybrids.

Combining ability studied using diallel analysis. After demonstrating by means of single factor analysis of variance the reliability of the experiment for the characters examined (P = 0.1% except for grain yield/plot, where P = 1.0—0.1%), the variances of general and specific combining ability were calculated using the method described (Table 2). Most characters gave significant results on the basis of both general (GCA) and specific (SCA) combining ability.

The data in Table 2 reveal that the rate of variance varies with the characters and is the highest for plant height. The significant GCA ratio means that in this case additive gene effects are primarily determinative, though non-additive gene effects cannot be neglected either, since the SCA variance is also significant. With thousand-grain-weight/main ear and spikelet number/main ear the proportion of genetic variance is considerably lower, so the importance of non-additive gene effects (dominance, epistasis) in the development of these characters is greater. This is even more the case with grain yield per plot. Similar results were obtained by Mihajlev—Borojevic (1974), Szunics *et al.* (1975), Matuz (1976), Mustafayev *et al.* (1978) and Tsilke *et al.* (1978).

For two characters, grain weight/plot and length of main ear, the variance of the specific combining ability exceeds that of the general combining ability. If the calculations are made on the basis of Griffing's 3rd method of model I (crossing without selfs) then the variance ratio of GCA is higher, as it is for the other characters. This supports the statement made by Turbin *et al.* (1974) that great care must be taken in choosing the genetic model.

Table 2

The mean squares of the characters

Characters	Source of variance			
	General combining ability	Specific combining ability	Error	GCA : SCA
Grain weight/plot	789.3*	511.0⁰	260.81	1.54 : 1
Grain weight/plant	1.8***	5.9*	0.30	0.30 : 1
Grain weight/main ear	0.6***	0.2**	0.06	3.00 : 1
1000-grain-weight/main ear	114.5***	12.8**	3.12	8.90 : 1
Spikelet number/main ear	4.8***	0.6**	0.19	8.00 : 1
Grain number/main ear	72.5*	64.1*	21.18	1.13 : 1
Length of main ear	0.2*	0.3	0.06	0.66 : 1
Plant height	1228.5***	15.5**	5.80	79.22 : 1

⁰ P = 10.0%; * P = 5.0%; ** P = 1.0%; *** P = 0.1%

Table 3

The general combining abilities of parents

Parents	Characters							
	Grain weight/ plot	Grain weight/ plant	Grain weight/ main ear	1000 grain weight/ main ear	Spikelet number/ main ear	Grain number/ main ear	Length of main ear	Plant height
Krasnodar 1	− 5.42	−0.66	−0.16	−2.79	−0.07	− 0.07	0.11	− 3.96
Kavkaz	6.91	0.31	0.37	3.62	1.11	4.09	0.14	11.06
Martonvásári 3	9.69	0.38	0.01	2.87	−0.43	−3.10	−0.17	8.64
Olesen	−11.17	−0.03	−0.21	−3.70	−0.60	−0.92	−0.09	−15.74
Standard error	8.23	0.52	0.07	0.54	0.18	1.41	0.13	0.73

According to the data in Table 3, the general combining ability of Kavkaz is good; this variety was placed first on the basis of five characters, followed by Martonvásári 3. Olesen took the first place for one character (plant height) and the last place for five. Krasnodar 1 was second for four, and third for four characters. In this experiment relatively high heterosis effects were generally obtained for those varieties whose general combining ability was also good. These observations confirm the data known from the literature (Kaltsikes—Lee 1971, Fedin—Silis 1973, Matuz 1976).

The general combining ability does not give information about any particular combination; conclusions on this can be drawn from the variance values of specific combining ability (Table 4). The combinations Martonvásári 3 × Olesen, Kavkaz × Olesen, Krasnodar 1 × Olesen and Krasnodar 1 × Kavkaz gave the best values of specific combining ability when evaluating a number of characters. Martonvásári 3 × Kavkaz showed poor combining ability.

In the hybrids the value of the specific combining ability was negative in 32 of the possible 96 cases (12 hybrids and eight characters). For combinations and characters where a better heterosis effect was coupled with a low or negative SCA value the heterosis effect may have been caused by additive-type genes, e.g. grain number/main ear in the Krasnodar 1 × Martonvásári 3 cross. In hybrids with good heterosis effects and high SCA values the heterosis effect may have been due to the action of non-additive-type genes (dominance, epistasis), e.g. the grain weight/plot and grain weight/plant data of Kavkaz × Olesen. It is a well-known fact that the value of specific combining ability in hybrids is related with dominance and epistatic genetic variance, so it is chiefly manifested in the F_1 generation.

Combining ability studied using multivariate analysis. The principal component analysis values of the parameters are presented in Table 5. The columns contain the weights of the principal components, but only for the first four components, since their cumulative value exceeds 96%, and the eigenvalue of the 4th factor is already < 1. In the first principal component the values of the different characters are significant and nearly identical, except for the productive ear number. The second component shows a much clearer distinction between the characters. The productive ear number, grain weight/plant, grain number/main ear and length of main ear gave positive values, while the thousand-grain-weight and plant height gave negative values. The first and second principal components cover seven of the nine characters examined, so details of the values for the third and fourth principal components are not given here.

Table 4

Values of specific combining ability in hybrids

Hybrids	Grain weight/plot	Grain weight/plant	Grain weight/main ear	1000 grain weight/main ear	Spikelet number/main ear	Grain number/main ear	Length of main ear	Plant height
Krasnodar 1 ×								
× Kavkaz	−4.16	−0.42	0.11	1.05	−0.02	1.11	0.02	2.57
× Martonvásári 3	−5.34	0.14	0.05	0.71	−0.17	−0.04	−0.11	0.98
× Olesen	14.23	1.20	0.06	−1.16	0.55	4.44	0.32	−1.22
Kavkaz ×								
× Krasnodar 1	−4.16	−0.42	0.11	1.05	−0.02	1.11	0.02	2.57
× Martonvásári 3	−0.32	−0.63	−0.34	−1.28	−0.47	−6.43	−0.36	0.28
× Olesen	11.68	2.17	0.29	3.90	0.27	2.29	0.12	1.56
Martonvásári 3 ×								
× Krasnodar 1	−5.34	0.14	0.05	0.71	−0.17	−0.04	−0.11	0.98
× Kavkaz	−0.32	−0.63	−0.34	−1.28	−0.47	−6.43	−0.36	0.28
× Olesen	15.07	0.90	0.29	1.50	0.46	5.48	0.39	2.90
Olesen ×								
× Krasnodar 1	14.23	1.20	0.06	−1.16	0.55	4.44	0.32	−1.22
× Kavkaz	11.68	2.17	0.29	3.90	0.27	2.29	0.12	1.56
× Martonvásári 3	15.07	0.90	0.29	1.50	0.46	5.48	0.39	2.90
Standard error								
$S_{(i,j)}$	15.02	0.96	0.13	0.98	0.33	2.57	0.24	1.30
$S_{(i,i)}$	20.16	1.29	0.18	1.32	0.45	3.45	0.32	1.80

The correlation matrix is presented in Table 6. Many characters showed medium close or close significant positive correlations. Of these, the relationship between the yield and the yield-forming components is worth mentioning. Plant height, as an important agronomical character, is in positive correlation with yield ($r = 0.61^{**}$), grain weight/main ear ($r = 0.68^{**}$),

Table 5

Weights of principal components

Characters	Principal components			
	I	II	III	IV
1. Grain weight/plot	0.793	0.003	0.433	0.328
2. Productive tillering	−0.029	0.861	0.456	0.012
3. Grain weight/plant	0.725	0.432	0.478	−0.213
4. Grain weight/main ear	0.967	−0.098	−0.080	−0.205
5. 1000-grain-weight/main ear	0.791	−0.485	0.317	−0.155
6. Spikelet/main ear	0.876	−0.039	−0.392	0.033
7. Grain number/main ear	0.806	0.393	−0.409	−0.090
8. Length of main ear	0.700	0.511	−0.405	0.194
9. Plant height	0.684	−0.660	0.156	0.117
Eigenvalue λ_i	5.09	2.03	1.24	0.32
Cumulative λ_i %	56.6	79.1	92.8	96.4

Table 6

Correlation matrix

Characters	Characters								
	1	2	3	4	5	6	7	8	9
1. Grain weight/plot	1.00	0.15	0.71	0.66	0.69	0.53	0.44	0.43	0.61
2. Productive tillering		1.00	0.55	−0.16	−0.29	−0.21	0.11	0.24	−0.47
3. Grain weight/plant			1.00	0.66	0.54	0.42	0.58	0.49	0.25
4. Grain weight/main ear				1.00	0.82	0.86	0.80	0.62	0.68
5. 1000-grain-weight/ main ear					1.00	0.57	0.32	0.17	0.90
6. Spikelet number/main ear						1.00	0.83	0.72	0.57
7. Grain number/main ear							1.00	0.90	0.21
8. Length of main ear								1.00	0.12
9. Plant height									1.00

Significance:

$R_{(P=0.05)} = 0.50$
$R_{(P=0.01)} = 0.61$
$R_{(P=0.001)} = 0.74$

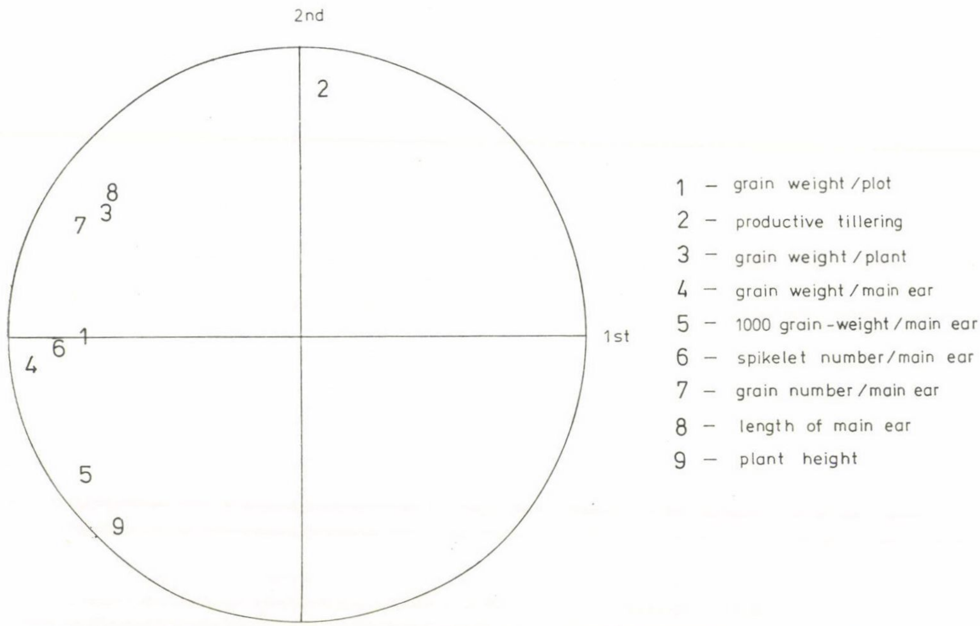

Fig. 1. **1st and 2nd principal component values of the characters studied**

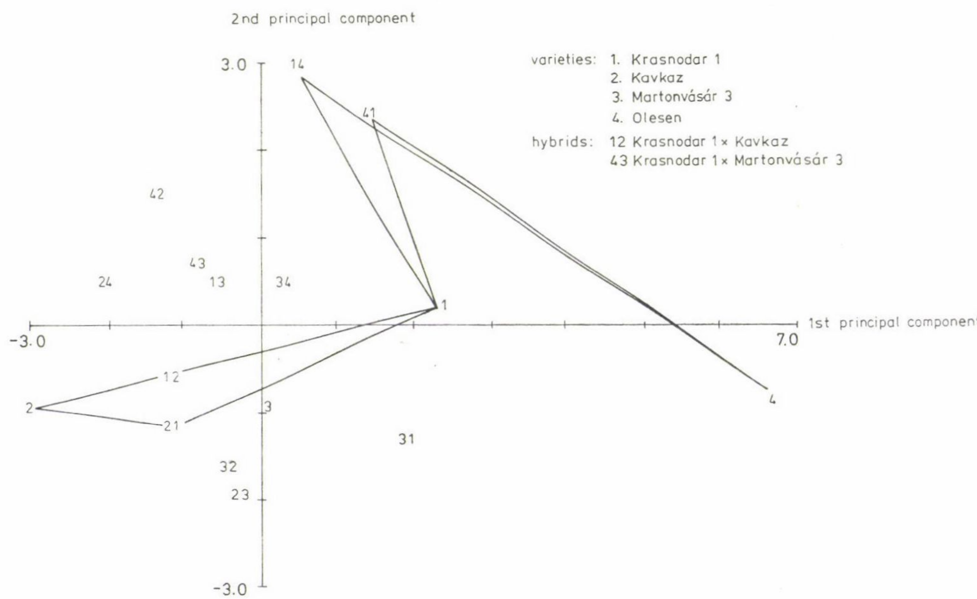

Fig. 2. **1st and 2nd principal component values of parents and F_1 hybrids**

thousand-grain-weight ($r = 0.90$***) and spikelet number ($r = 0.57$*). At the same time, the investigations showed a non-significant correlation between plant height and grain weight/plant, plant height and grain number/main ear, and plant height and length of main ear. The positive correlation between plant height and productivity has been mentioned by a number of authors (TORRIE 1936, LEGRAND 1966, BALLA 1968, 1973). This does not, however, exclude the possibility of producing short-strawed, high-yielding varieties (LUKYANENKO 1969, KOLTAY—BALLA 1975, POTOCANAC 1976).

Figure 1 shows the characters examined in the co-ordinate system of components I and II. On this basis characters 1, 6 and 4; 7, 3 and 8; and 5 and 9 form groups. Productive tillering is isolated from all the other characters; this is due to the wide spacing of the plants.

On the basis of the three-dimensional distances, groups of certain characters can be determined even more precisely. The correlation between two characters is considered to be close when the distance between them is less than half the average distance. The average distance for all the character combinations is $d = 0.86$; for grain number/main ear — spikelet number: $d = 0.04$; for plant height — grain number/main ear: $d = 0.11$; for plant height — spikelet number/main ear: $d = 0.13$; for plant height — grain weight/main ear: $d = 0.26$; for grain weight/main ear — grain number/main ear: $d = 0.29$; for grain weight/plant — grain number/main ear: $d = 0.37$; for plant height — grain weight/plant: $d = 0.42$.

The first and second principal component values of the parents and F_1 hybrids for the nine characters studied (Table 5) are shown in Fig. 2. The varieties differ from one another. The hybrids Krasnodar 1 × Olesen and Olesen × Krasnodar 1 show considerable differences compared to the parents due to the high heterosis effect expressed in many characters. In fact, all those combinations which have Olesen as one of the parents show heterosis on the basis of the totalled values. This can be explained by the fact that dwarfness and productivity make up a considerable proportion (Table 5, second main component).

The direct (12) and reciprocal (21) hybrids of Krasnodar 1 and Kavkaz are obviously close to one another on the basis of the characters evaluated, and show intermediate inheritance relative to the parents. In the F_1 hybrids, with the exception of Krasnodar 1 × Martonvásári 3, no significant reciprocal effect was found. The progenies of Kavkaz × Martonvásári 3 and Martonvásári 3 × Kavkaz are inferior to the parents. The figure clearly shows the distance of the hybrids from the parents and the extent of the reciprocal effect if there is any.

The multivariate analysis produced results fundamentally similar to the data of Griffing's combining ability examinations. Multivariate analysis has the great advantage that it enables hybrid populations to be evaluated and the method of selection to be decided on, on the basis of more than one character at a time.

There is a certain relationship between the yield and the breeding importance of the F_1 hybrid, and this can be utilized in variety production (KIRICHENKO 1967). According to LUKYANENKO (1949) the best progenies are generally derived from parents with a number of favourable characters which are satisfactorily recombined in the progeny.

*

Prepared at the Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvásár.

L. SZUNICS, A. ÁBRÁNYI, L. BALLA

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EXPERIENCE GAINED WHEN USING HONEYBEES FOR POLLEN DISPERSION IN HYBRID SUNFLOWER SEED PRODUCTION

One possible means of increasing the yield per unit area in a given crop is by carrying out hybridization. In the case of sunflower this requires the establishment of genetic systems, the regular operation of which removes the difficulties related with the peculiarities of flowering biology and thus makes the application of large-scale hybrid production methods possible (Frank 1978). These methods have been available to breeders for some years. However, the technical level and profitability of seed production still present a serious problem.

How to preserve the genetic characteristics of the lines is of great concern. Apart from gross errors caused by the mixing of seeds (which may well occur at farm level), the entomophilous character of the sunflower must also be taken into consideration (Gubin 1958). Owing to the spread of commercial sunflower production, it is increasingly difficult to ensure optimum isolation distances at farm level. A serious problem is caused by the fashion of sowing sunflowers for ornamental purposes or as a border plant in the homeplots of farm workers or in cultivated plots on detached farms. The situation is complicated by the damage done by game and birds from sowing till harvesting (Vranceanu 1977).

In the case of base farms which produce hybrid seed for sowing, the profitability of this activity is the primary viewpoint. Unfortunately, the annual fluctuations of yield at present go beyond the extent acceptable at farm level. With the right honeybee density a profitable yield can be obtained from maternal and paternal lines with different vegetation periods by ensuring synchronised flowering. It is for this purpose that the method of periodical sowing and the use of recessively branching genotypes as pollen donors, or rather, a combination of the two methods, has been elaborated (Vranceanu 1977).

The questions arises of whether periodical sowing could be terminated, thus reducing the operational expenses, and whether more homogeneous pollination of the inflorescences of mother plants could be achieved with a resulting increase in yield. According to our theory, controlled pollination with the help of honeybees, insofar as it is feasible, might bring us closer to the solution. The use of pollen previously gathered and then dispensed from beehives was also considered, as pollen supplied from hives by honeybees had been successfully used in several cases to increase the volume of fruit in orchards (Bonfante 1972, Overly—O'Neill 1976).

The role of honeybees in the isolated and open pollination of sunflower was clarified in preliminary studies (Farkas—Petőházi 1977).

The present experiment was aimed at finding out

— whether honeybees flying out of the hive can be used to distribute hand-collected sunflower pollen with the aid of the given pollen dispenser;

— what effect genetically homogeneous and heterogeneous pollen mixtures have on achene weight and oil content in male sterile sunflower compared to male sterile sunflower isolated without honeybees.

The experiments were set up in 1977 at Kiszombor, in a random block design with three replications. Seeds were sown at a distance of 30 cm in rows spaced at 60 cm. Iron frames 2 m high and covered with netting were placed over the 6 m^2 plots before flowering. In the net-covered plots hives with low (18 cm) frames were set up, thus ensuring some 500 to 1000 worker honeybees for each plot. By occasionally fitting a pollen dispenser onto the hive the pollen collected by hand in advance was caused to be distributed by the honeybees. The dispersed pollen was collected using a Szabó-type pollen collector from the variety GK-70, from 30 inbred lines derived from the variety Czernianka 66, and from hybrid combinations of these lines produced on an HR-0 male sterile mother.

The pollen collector devised by the authors is a "comb" that makes it possible to collect large masses of pollen without injuring the stigmae.

The treatments were:

I. Male sterile and male fertile analogous lines without bees (control).
II. Male sterile and male fertile analogous + male fertile non-analogous line pollinated by bees.
III. Exclusively male sterile plants + bees + pollen dispersion from hive.
IV. Male sterile and male fertile analogous + male fertile non-analogous line + bees + pollen dispersion from hive.

The HR-0 line was used as an alternative to genically male sterile and male fertile analogous lines, the 360/1977 line as a cytoplasmic male sterile mother, and the 391/1977 restorer line as a non-analogous male fertile alternative.

The oil content of the achenes was determined by measuring the oil previously extracted with a Soxhlet apparatus, and was expressed as percentage dry weight.

The results are summarized in a table, the data of which clearly show that pollination with fertile pollen distributed by honeybees with the aid of a dispenser was successful (Table 1).

In an isolated area, thickly sown genically male sterile sunflower becomes partly fertilized owing to the flowers bumping against one another and because of the wind. The achene and oil produced in such crops can be regarded as the results of pollination with homogeneous pollen (I.1, 2, 3/a).

Cytoplasmic male sterile sunflower did not become fertilized because of the exclusion of pollen and bees (I.1, 2, 3/b).

The highest yield of all the experimental combinations was achieved in treatment II due to the activity of bees. This is quite natural, since in this case the conditions were even more favourable than the natural process of entomophilous pollination. The pollen was obtained from two lines. The oil contents of achenes in the genic and cytoplasmic mother lines (II.3/a and b) were identical.

There was an 8.7% difference in oil content between the first two treatments (I.3/a and II.3/a), presumably due to the presence of pollen from the genetically non-analogous line.

The best fertilization was achieved with pollen distributed by bees from the hive; only 2.6% of the flowers in the middle of the inflorescence remained unfertilized (III.2/b). The oil content of the achene showed a further 2% increase, probably because of the mixed pollen applied (III.3/b).

Treatment IV can be regarded as a combination of treatments II and III. The oil contents of achenes both in the genic and cytoplasmic sterile mother line were the highest (49.7 and 51%, respectively) in this treatment, probably due to the favourable genetic characters of the restorer line 391/1977 in this respect.

Table 1

Results of pollen dispersion by honeybees to pollinate male sterile sunflower lines

Treatment combination	(1) Yield, g/plant		(2) Percentage of unfertilized flowers		(3) Oil content of achene as percentage dry weight	
number description	(a) GSt	(b) CSt	(a) GSt	(b) CSt	(a) GSt	(b) CSt
I. Male sterile line + male fertile analogous line without bees	7.41	—	65.7	100.0	57.8	—
II. Male sterile line + male fertile analogous line + male fertile non-analogous line + bees	62.8	131.0	10.0	5.3	46.5	47.2
III. Male sterile line + bees + dispersion of pollen mixture	—	90.1	—	2.6	—	49.1
IV. Male sterile line + male fertile analogous line + male fertile non-analogous line + bees + dispersion of pollen mixture	52.0	91.1	11.7	4.3	49.7	51.0
$LSD_{5\%}$	—	—	8.2	3.7	1.7	1.5

Abbreviations:

GSt = genic male sterile line
CSt = cytoplasmic male sterile line

From the results of the experiment it is clear that the pollen from the pollen dispenser fitted onto the entrance of the hive stuck to the honeybees and was thus carried onto the stigmae of the sunflowers. With the right number of bees and viable pollen the extent of fertilization is not likely to be worse than when sowing alternating rows of male sterile maternal and male fertile paternal lines in several periods, as is traditionally done in hybrid seed production.

This method should thus be tried out on a farm scale. This would mean that sowing could be simplified, yield reliability increased, and the economic efficiency of seed production improved. The danger of asynchronous flowering in the maternal and paternal lines, which may be caused by the ecological conditions, would be eliminated, the tiring and time-consuming breeding and production needed for this purpose would become unnecessary, and at the same time the genetic purity of the paternal line could easily be maintained.

This method seems suitable for studying the effect of pollen originating from genetically different lines and hybrids on the oil content.

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Prepared at the Research Institute for Small Animal Breeding, Gödöllő, and Cereal Research Institute, Szeged.

J. FARKAS, J. FRANK

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SEMICONTINUOUS CULTIVATION OF CHLAMYDOMONAS GEITLERI ETTL IN WASTE WATER

Microscopic fresh-water algae are becoming increasingly important model organisms in both pure and applied research. They find a ready application in technical hydrobiology as testing organisms and provide a source of strains suitable for colonizing biological reservoirs of different types, mainly those attached to water treatment plants. This purpose is fulfilled by algal strains capable of intensively withdrawing mineral nutrients, especially N and P, from the environment and strains tolerating some substances that may be present in high concentrations in some types of waste waters.

Algal growth depends to a considerable extent on temperature; below a certain temperature threshold the growth stops. This restricts the time interval for which the algae may be cultivated under open-field conditions. The problem may be solved, for example, by using algal strains which grow well even at reduced temperatures, as documented by this study.

An important factor in the utilization of the cultivated algal biomass harvested in waste water is its chemical composition, especially with respect to heavy metals.

Mathematical relationship used for evaluation

In a semicontinuous culture, a portion of the suspension volume, V_1, is regularly withdrawn from the cultivation device containing a total volume of algal suspension V ($V_1 < V$). The volume withdrawn, V_1, is replaced by an identical volume of waste water. With one sampling per day, the dilution rate of the semicontinuous culture will be defined by the equation $D = V_1/V$.

Let us assume that the cultivation of algae at any one dilution rate proceeds for a number of days so that the state of the culture may be described by averaged quantities for the time interval ΔT (cultivation period). The average quantity $\bar{y}$ is defined as:

$$\bar{y} = \frac{1}{\Delta T} \int_0^{\Delta T} y \cdot \mathrm{d}t \tag{1}$$

The averaged values will be denoted by a bar above the appropriate symbol.

The balance of algal concentration in a semicontinuous culture is given by the formula:

$$\bar{r} = D\bar{w} \tag{2}$$

where $\bar{r}$ is the algal growth rate, D the dilution rate and $\bar{w}$ the algal concentration. It is assumed in formula (2) that the dilution rate is constant within the time interval ΔT.

The balance of a nutrient removed by the algae in a semicontinuous culture is given by the formula:

$$D(C_0 - \bar{C}) = \frac{\bar{r}}{Y} \tag{3}$$

where $\bar{C}$ is the concentration of the nutrient in the suspension, C_0 the concentration of the nutrient in waste water fed into the device and Y the yield coefficient (g algae/g nutrient). The quantities D, C_0 and Y in formula (3) are assumed to be time-independent. Formulas (2) and (3) give a relationship for the yield coefficient Y:

$$Y = \frac{\bar{w}}{C_0 - \bar{C}} \tag{4}$$

The degree of removal of a nutrient from the waste water by means of the algae may be expressed by the formula:

$$\% \text{ removal} = \frac{C_0 - \bar{C}}{C_0} \tag{5}$$

It may be expected that both the algal concentration $\bar{w}$ and the yield coefficient Y will also depend on the dilution rate. Under variable open-field conditions this dependence is best determined experimentally.

Algal strain. Experiments were carried out on the alga *Chlamydomonas geitleri* ETTL strain ETTL 1966/3. Its growth characteristics in a wide temperature interval and at three different illumination intensities have been described elsewhere (Tetík—Nečas, 1977). The temperature dependence of the growth rate of this strain differs considerably from that of many other strains. In comparison with some chlorococcal algae, e.g. *Scenedesmus* or *Chlorella*, *Chlamydomonas geitleri* grows relatively rapidly even at low temperatures, at which these chlorococcal algae exhibit slow or no division and their growth stops. The selected strain grows at low temperatures more satisfactorily than some other strains of the genus *Chlamydomonas*. As noted by Tetík—Nečas (1977), *Chlamydomonas geitleri* ETTL grows in a temperature interval of 4—28°C, with the highest growth rate values at 15—25°C.

Waste water. The waste water was obtained from a water processing plant catering for municipal sewage and waste water from a large-scale hoggery. The imported water was stored in a 2500 l open tank. During storage it became contaminated with algae, predominantly *Chlorella*. The variability of waste water during storage is illustrated in Table 1. The comparison with the composition of the algal nutrient medium (Šetlík, 1967) with respect to nitrogen (560 mg/l) and phosphorus (155 mg/l) shows that the concentration of these biogenic elements in the waste water is about 10-fold lower.

As stated by Soeder (1972), the algal dry matter contains on average 8.5% N and 1% P, the N : P ratio being thus 8.5 : 1. Table 1 shows that the N : P ratio is about 1 : 1; to achieve a balanced N : P ratio, the waste water must be supplemented with nitrogen. This was attained by adding urea in such a way that the nitrogen concentration was increased by 280 mg/l.

Chemical analysis of waste water after cultivation and analysis of algal biomass was carried out in average samples. These samples were obtained by mixing the accumulated algal suspension in a cooling tank (volume 500 l) after the termination of the experiments at a given dilution rate. The waste water was analysed after the separation of the algae; the remaining biomass was lyophilized and then analysed.

Table 1

Some characteristics of waste water used for

Date of sampling for analysis	Sample	pH	BOD	COD	Acidity	Alkalinity	Conductance
			mg/l		mval/l		μS/cm
30. 5. 1978	015	7.9	78	320	5.0	12.8	1420
9. 6. 1978	016	8.1	44	150	2.2	10.4	8

* Waste water was imported on May 11th 1978

Experimental device. The principle of the cultivation device is illustrated in Fig. 1. Algal suspension passes down the cultivation area (1) on top of which it is transported by an excentric pump (3) from a retention tank (2). The mixing during the flow of suspension down the cultivation area is achieved by baffles positioned at right angles to the flow direction. The retention tank serves for the control of suspension volume and as a reservoir in the case of pump (3) failure. The saturation of the suspension by carbon dioxide is done from a pressure cylinder via a pressure reduction valve; the CO_2 feed is attached to the suction pipe of the pump (3).

The intensity of CO_2 dosage is checked by means of the intensity of bubbling of the gas through a water column in a glass flask inserted into the CO_2 inlet.

Cultivation of algae. A portion of the suspension volume was withdrawn from the cultivation device once a day and was replaced by the same volume of waste water. The concentration of nitrogen in the waste water was enhanced by adding urea to each new dose. Evaporation losses were also compensated by tap water to the total colume of 150 l. Suspension extinction was determined once a day at 750 nm in a 1 cm cuvette (at this wave length the light is not absorbed by chlorophylls); the suspension temperature was determined at 7 a.m., 11 a.m. and 1 p.m. Recirculation of algal suspension on the cultivation area proceeded overnight; no saturation with CO_2 was provided in the night. The cultivation parameters are summarized in Table 2.

Algal cells kept in the cooling tank sedimented. After the separation of the fluid the sedimented algae were lyophilized. The determined mass of the lyophilized biomass and the suspension volume in the tank were used in calculating the mean algal concentration $\bar{w}$. This procedure was adhered to at each dilution rate.

Algal growth. Table 3 shows that with increasing dilution rate the mean algal concentration $\bar{w}$ in the suspension declines. The algal concentration in open-field conditions varies daily even at a constant dilution rate (Fig. 2). These variations are understandable in view of the variable suspension temperature and illumination that depends on climatic conditions.

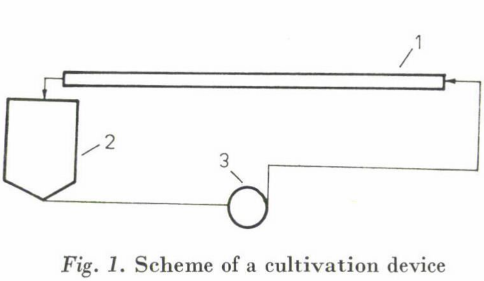

Fig. 1. Scheme of a cultivation device

*cultivation of Chlamydomonas geitleri**

Soluble substances dry weight/ashes	Insoluble substances dry weight/ashes	N total	P total	K	Na	Ca	Mg
		mg/l					
588/310	53/13	18	15.7	78	36	22	13
—	—	13	19.6	70	34	19	20

Figure 3 indicates that the extinction of a suspension of *Chlamydomonas geitleri* is roughly proportional to the algal concentration.

The rate of algal growth $\bar{r}$ in formula (2) depends on the dilution rate D and algal concentration $\bar{w}$. Since $\bar{w}$ also depends on D (Table 3), $\bar{r}$ will be a function of the dilution rate D. The experimentally determined dependences of the growth rate on the dilution rate are seen in Fig. 4. The maximum growth rate is attained at a very low dilution rate (0.067 day^{-1}).

Table 2

Parameters of cultivation of Chlamydomonas geitleri in waste water

Cultivation period (1978)	Sample	Dilution rate, day^{-1}	pH	Suspension temperature, °C 9 a.m.	11 a.m.	1 p.m.	Mean temperature, °C
14. 5.—22. 5.	B/78	0.067	7.6	9.6	15.2	15.9	13.6
22. 5.—29. 5.	C/78	0.133	7.9	13.6	19.5	20.1	17.8
29. 5.— 5. 6.	D/78	0.200	8.0	14.3	25.2	26.1	21.9
6. 6.—12. 6.	E/78	0.333	8.1	16.6	23.8	23.7	21.4
13. 6.—19. 6.	F/78	0.500	7.8	11.6	22.3	23.6	19.2

Table 3

Time course of algal concentration, BOD_5 and COD in a semicontinuous open-field culture of Chlamydomonas geitleri

Cultivation period (1978)	Dilution day^{-1}	Mean algal concentration, mg/l	BOD_5 inlet	BOD_5 outlet	BOD_5 removed, %	COD inlet	COD outlet	COD removed, %
			mg/l			mg/l		
14. 5.—22. 5.	0.067	732	78	32	59.0	320	250	21.9
22. 5.—29. 5.	0.133	277	78	16	79.5	320	290	9.4
29. 5.— 5. 6.	0.200	132	78	47	39.8	320	200	37.5
6. 6.—12. 6.	0.333	98	44	47	−6.8	150	220	−21.9
13. 6.—19. 6.	0.500	70	44	20	54.5	150	280	−86.7

Removal of nutrients from waste water. Table 4 gives the N and P balance in the waste water effluent after the cultivation of *Chlamydomonas geitleri*. As seen in Fig. 4, the percentage removal of N and P declines with increasing dilution rate, attaining a maximum at a dilution rate corresponding to the maximum growth rate of *Chlamydomonas*. The results of other analyses of the waste water after the cultivation of algae are given in Table 5; no significant effect of the dilution rate is discernible on the analysed quantities.

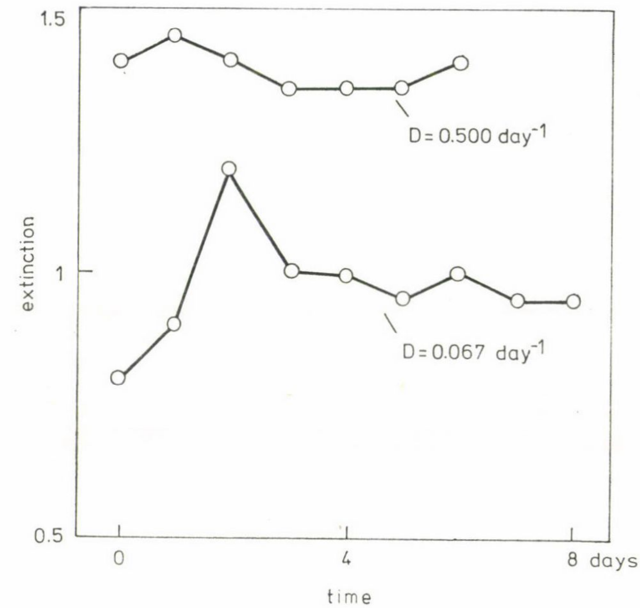

Fig. 2. Time course of extinction of *Chlamydomonas geitleri* suspension during cultivation at two dilution rates

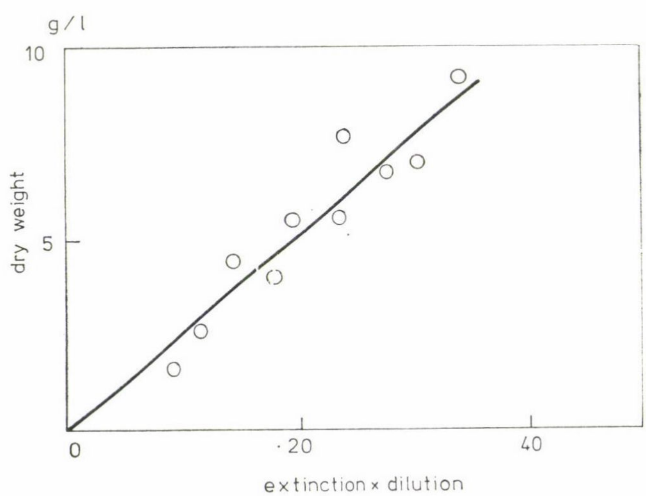

Fig. 3. Dependence of *Chlamydomonas geitleri* dry weight on suspension extinction

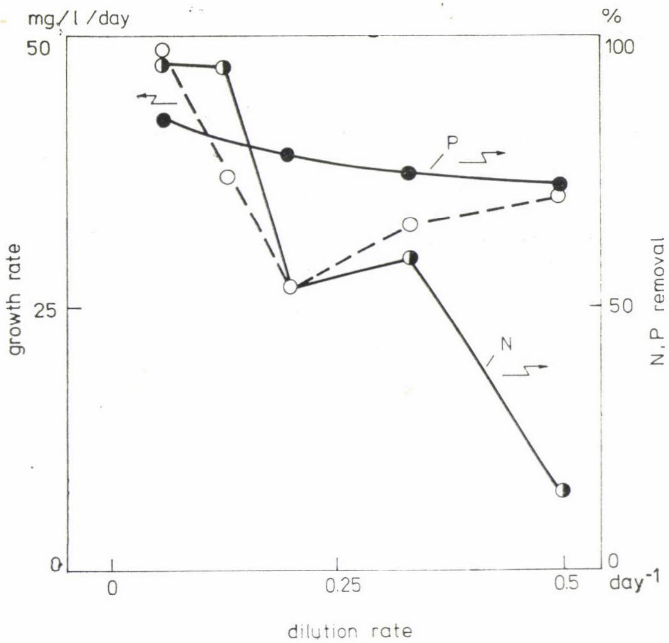

Fig. 4. Dependence of the growth rate of *Chlamydomonas geitleri* in waste water on dilution rate and percentage removal of total N and P from waste water

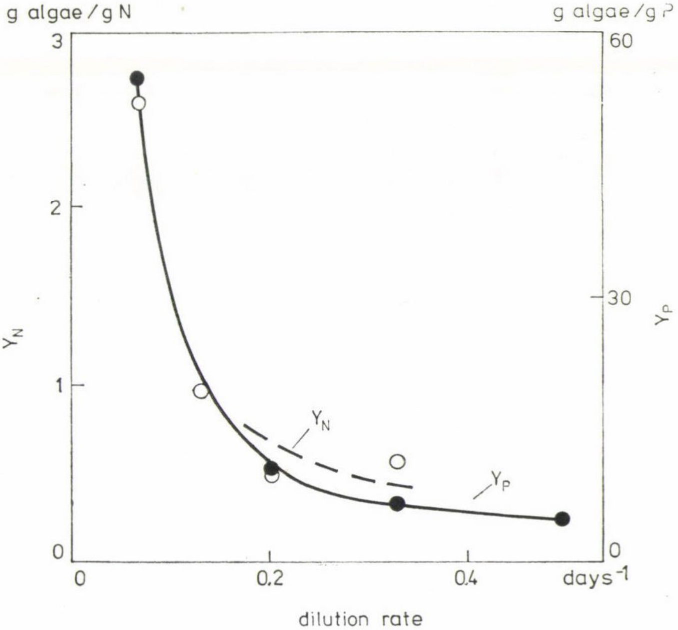

Fig. 5. Effect of dilution rate on the yield coefficient Y for nitrogen and phosphorus in a culture of *Chlamydomonas geitleri* in waste water (0 — Y_N; 0 — Y_P)

The effect of dilution rate on the yield coefficient Y (g algae/g removed element) with respect to nitrogen and phosphorus is seen in Fig. 5. An analogous trend of Y_P was described by NYHOLM (1977) in an axenic culture of *Chlorella pyrenoidosa*. A semicontinuous open-field culture of *Scenedesmus acutus* in municipal refuse and large-scale hoggery effluent (LÍVANSKY *et al.* 1979) was also found to exhibit a similar dependence of Y_N and Y_P on dilution rate.

Table 4

Total N and P balance in waste water after cultivation of Chlamydomonas geitleri

Cultivation period (1978)	Dilution rate, day^{-1}	Total N inlet	Total N outlet	Total P inlet	Total P outlet
		mg/l			
14. 5.—22. 5.	0.067	298	15	15.7	2.4
22. 5.—29. 5.	0.133	298	16	15.7	—
29. 5.— 5. 6.	0.200	298	140	15.7	3.4
6. 6.—12. 6.	0.333	293	122	19.6	5.1
13. 6.—19. 6.	0.500	293	251	19.6	5.1

Table 5

Analysis of waste water after cultivation of Chlamydomonas geitleri

Cultivation period (1978)	Sample	pH	Dilution rate, day^{-1}	Acidity	Alkalinity	Conductance, μS/cm	Soluble substances dry weight/ashes	Insoluble substances dry weight/ ashes	K	Na	Ca	Mg
				mval/l					mg/l			
14. 5.—22. 5.	B/78	7.75	0.067	0.9	2.1	700	642/358	6/0	49	51	26	26
22. 5.—29. 5.	C/78	8.85	0.133	0.0	10.0	1200	542/310	0/0	45	33	21	28
29. 5.— 5. 6.	D/78	8.20	0.200	0.0	9.9	1220	522/296	5/1	54	30	20	15
6. 6.—12. 6.	E/78	7.95	0.333	1.0	8.8	1160	534/304	3/0	54	39	22	19
13. 6.—19. 6.	F/78	8.15	0.500	1.0	10.6	1350	500/244	1/0	60	29	23	13

Table 6

Some characteristics of pond water (Opatovicky pond)

Sampling date (1978)	Sample	pH	BOD	COD	Acidity	Alkalinity	Conductance, μS/cm	Soluble substances dry weight/ ashes	Insoluble substances dry weight/ ashes	N total	P total	K	Na	Ca	Mg
			mg/l		mval/l					mg/l					
10. 6.	018	8.0	14	55	0.20	0.95	216	190/146	22/13	3.5	0.25	7	9.8	21	8.5
28. 7.	019	7.9	8	20	—	0.20	184	184/124	13/8	3.5	0.25	7	9.5	21	9.1
28. 8.	020	8.2	5.5	48	0.05	1.20	216	496/418	19/14	2.8	0.25	6.2	9.5	18	11

Algae contain on average 8.5% N and 1% P in their biomass (Soeder 1972). These data are approximately confirmed by the analysis of *Chlamydomonas geitleri* biomass (see below). Values of Y_N and Y_P in Fig. 5 are too low compared to these data; this indicates that both N and P in our case were removed from the waste water by some other, physicochemical mechanism, not only by incorporation into the algal cells.

If the concentration of N and P in waste water should be lowered to the concentration of these elements, in pond water for example (cf. Table 6), the dilution rate would have to be lower than 0.067 day^{-1}. This gives rise to the requirement of still lower concentrations of N and P in the processed waste water, with a concomitant retention of a favourable N : P ratio adjusted possibly by an addition of the elements.

Biochemical and chemical oxygen demand in the waste water after the cultivation of the alga *Chlamydomonas geitleri* is shown in Table 3, which indicates that in some cases both these quantities increase. The reason for this increase in BOD and COD is unknown and may be attributed to the decomposition of dead algal cells, which causes a release of oxidizable substances into the environment.

The state of the algal culture. During the cultivation of *Chlamydomonas geitleri* in waste water at higher temperatures the alga *Chlorella* appeared as a contaminant; at a dilution rate of 0.5 day^{-1} the contamination reached 50%. *Chlorella* invaded the suspension of *Chlamydomonas* mainly via the waste water fed from a tank with a surface growth of *Chlorella*. Under

Table 7

Composition of Chlamydomonas geitleri cultivated on waste water

Cultivation period (1978)	Sample	Dry weight	Fat	Acid number of fat, mg KOH/g	Ashes	N	P	K	Na	Ca	Mg
		%			%						
14. 5.—22. 5.	B/78	90.4	8.0	91.3	7.6	7.94	1.22	0.37	0.33	0.24	0.19
22. 5.—29. 5.	C/78	—	4.6	87.4	8.0	8.07	0.72	0.45	0.36	0.57	0.17
29. 5.— 5. 6.	D/78	—	3.9	74.0	7.5	8.25	0.71	0.27	0.16	0.64	0.20
6. 6.—12. 6.	E/78	88.9	4.5	97.8	8.5	7.62	1.08	0.32	0.14	0.53	0.29
13. 6.—19. 6.	F/78	95.3	2.4	60.7	10.9	7.15	1.53	0.55	0.16	0.68	0.25

Table 8

Composition of biomass of Chlamydomonas geitleri cultivated on waste water

Cultivation period (1978)	Sample	Pb	As	Zn	Cu	Fe	Mn	Cd	Ni	Cr	Co
		mg/kg biomass									
14. 5.—22. 5.	B/78	—	—	5460.6	176.4	—	103.8	3.39	18.31	—	—
22. 5.—29. 5.	C/78	7.03	1.08	451.9	1.5	0.06	—	—	—	—	—
29. 5.— 5. 6.	D/78	17.53	1.15	339.4	69.7	0.01	—	—	—	—	—
6. 6.—12. 6.	E/78	8.84	1.00	4719.9	345.5	—	187.5	4.55	30.54	3.17	9.91
13. 6.—19. 6.	F/78	—	—	8438.0	443.0	—	338.5	7.50	14.53	—	—

open-field conditions the contamination with *Chlorella* could not be prevented and some of the experimental values obtained may thus be affected in an uncontrollable manner.

Composition of algal biomass is given in Tables 7 and 8. The Tables give no indication of any significant trend in the analysed quantities during the cultivation period. The mean content of N (7.8%) and P (1.05%) in the biomass (Table 7) is in keeping with the data of SOEDER (1972): 8.5% N and 1% P for autotrophic algae.

Bacteriological examination of samples of *Chlamydomonas* biomass showed the presence of saprophytic microflora. Mycological examination demonstrated the moulds *Mucor* and *Aspergillus* (60—2000 germs per 1 g biomass).

It was proved experimentally that the alga *Chlamydomonas geitleri* may be successfully used for removing N and P from waste water during the spring months, with a concomitant production of algal biomass. In view of the relatively long cultivation, the efficient removal of N and P would require the lowering of the concentration of the elements in the outlets of the treatment plants.

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Prepared at the Biotechnological Laboratory, Institute of Microbiology, Czechoslovak Academy of Sciences, Třeboň; Faculty of Agriculture of the Keszthely University of Agriculture, Mosonmagyaróvár.

K. VÉBER, B. PROKEŠ, K. LÍVANSKÝ, G. MÁRTON

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CONTRIBUTION TO THE BIOLOGY OF DIAPORTHE PHASEOLORUM (CKE. ET ELL.) SACC. VAR. SOJAE WEHM. (SYN.: D. SOJAE LEH.); IMP.: PHOMOPSIS SOJAE LEH., A PATHOGEN CAUSING A NEW SOYBEAN DISEASE IN HUNGARY

The import of seed for use in variety trials, breeding and commercial production represents a potential danger of introducing pathogens so far unknown in Hungary. The pathogen *Phyllosticta sojaecola* Massalem was described in Hungary by VIOLA (1969), while information on the occurrence of *Corynespora cassiicola* (Berk. et Curt.) Wei was given by ÉRSEK (1978a, b). An account of the appearance of *Ascochyta sojaecola* Abramov in Hungary was given by TÓTH—KÖVICS (1978).

Pod and stem blight in soybean is caused by the pathogen *Diaporthe phaseolorum* (Cke. et Ell.) Sacc. var. *sojae* Wehm. (Syn.: *D. sojae* Leh.); imp.: *Phomopsis sojae* Leh. (LEHMAN 1923, LUTTRELL 1947, ATHOW—CALDWELL 1954, HILDEBRAND 1956, WALLEN—SEAMAN 1962, PETERSON—STRELECKI 1965, NOBEL—RICHARDSON 1968, DUNLEAVY 1969, KMETZ *et al.* 1974, etc.).

The damage done by the pathogen in Hungary was observed by SZILI (1975) on the stems and pods of soybeans in Szolnok and Tolna counties. He found the degree of infection to be 6—12%, and the damage done to the variety G SZ.3 to be the most serious in both counties. The occurrence of the fungus in Győr-Sopron county was reported by SZALAY (1976). The appearance of the disease was observed in summer 1976 in Debrecen (East Hungary) in the soybean varieties Merit and Steele.*

The pathogen was first observed in the United States in 1920 (LEHMAN 1923). Its occurrence has since been reported from Brazil, Canada, Colombia, Guyana, India, Japan, China, Malawi, Taiwan and the Soviet Union (PATINO 1967, SIDDIQUI 1971, SINCLAIR—SHURTLEFF 1975).

Before 1960 the disease was considered to be of minor importance (SASAKI 1929, LUTTRELL 1947, ATHOW—CALDWELL 1954, HILDEBRAND 1956). It has since been found that the germinative ability of seeds severely infected by the fungus significantly decreases (WALLEN—SEAMAN 1963, ELLIS *et al.* 1974, 1976). Mouldy, inferior seeds infected by *Phomopsis sojae*, a pathogen causing considerable damage, are common in Brazil, Canada and the United States (WALLEN—SEAMAN 1963, CRITTENDEN—SVEC 1974, CHAMBERLAIN—GRAY 1974, BOLKAN *et al.* 1976). Besides *Diaporthe phaseolorum* var. *sojae*, major fungi infecting the seed of soybean are: *Diaporthe phaseolorum* var. *caulivora*, *Cercospora kikuchii*, *Alternaria* spp., *Aspergillus melleus*, *Aspergillus niger*, *Fusarium scirpi* var. *acuminatum*, *Fusarium gibbosum* and *Ascochyta sojaecola* (KILPATRICK 1957, MA 1967, WILCOX—ABNEY 1971, ATHOW 1973, KIS *et al.* 1977, TÓTH—KÖVICS 1978). In susceptible soybean varieties the *Phomopsis* infection of the seeds often exceeds 50%, especially when the harvest is delayed and wet, hot weather prevails (WILCOX *et al.* 1974, ELLIS *et al.* 1976, SINCLAIR 1977). As described by plant producers, physiologists and pathologists, delayed harvesting results in the "weathering" of soybean seeds (BAILEY 1964, GREEN *et al.* 1966, DE LOUCHE 1975, RACHIE—PLARRE 1975). According to the investigations of SZALAY (1976) the rate of infection by *Diaporthe phaseolorum* var. *sojae* in seed lots produced from imported seed was 1—3%.

The symptoms of the disease

Infection may occur on the stem, petiole, pod or seed, or less frequently on the leaf. Seriously infected plants may die. The fungus produces large numbers of pycnidia, mainly on the lower part of the stem, where branching occurs or on the pods at about the time of ripening.

On the stem the pycnidia mostly appear in a line ("tiger spots", Fig. 1) or in well defined lesions (Fig. 2), generally near the nodes.

On the maturing pods the pycnidia show a scattered arrangement (Fig. 3). In spite of strong infection of the stem SZALAY (1976) found no pods on which spores had developed.

On seriously infected seeds the spots become deeply cracked and dry out, while the seed are often partially or completely coated with the white mycelium of the fungus. Besides *Diaporthe phaseolorum* var. *sojae* the fungi *Cercospora kikuchii* (ROY—ABNEY 1976, MA 1967) and *Diaporthe phaseolorum* var. *caulivora* (KMETZ *et al.* 1978) also form mouldy coatings.

On the cotyledons of seedlings developing from infected seeds lesions ranging from nearly colourless to a light reddish-brown colour are formed and may even attain the full size of the cotyledon. Below the hypocotyl a narrow reddish-brown spot some 1.5 cm in length appears. The seedling may become deformed or totally destroyed.

Symptoms are less frequently found on the leaves; the infection usually takes place below the apical part of the leaflet and advances towards the petiole. The whole leaflet may eventually be destroyed (SINCLAIR—SHURTLEFF 1975).

* Data have recently been published by ÉRSEK (1978c, 1979) on the mycological characteristics of *Diaporthe phaseolorum* var. *sojae (Phomopsis sojae)*, a new pathogen in Hungary.

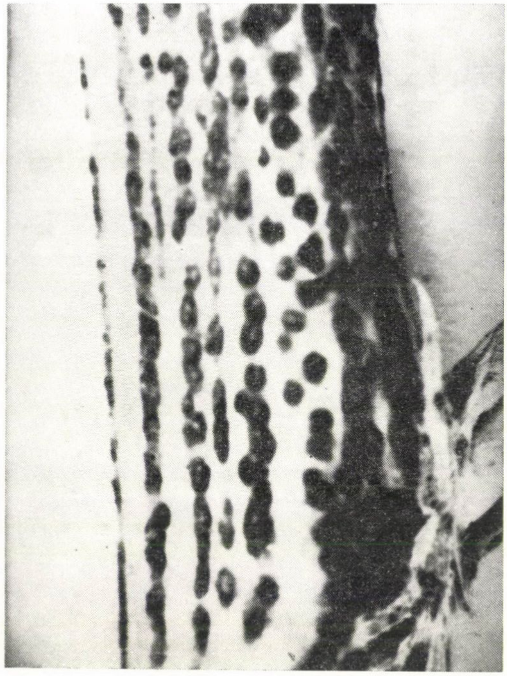

Fig. 1. Phomopsis sojae pycnidia arranged in a line on soybean stem ("tiger spots")

The morphology of the fungus

The imperfect form of the pathogen (*Phomopsis sojae* Leh.) is more frequent, while the perfect form [*Diaporthe phaseolorum* (Cke. et Ell.) Sacc. var. *sojae* Wehm.] seldom appears, probably because the fungus is heterothallic, i.e. a single specimen is not capable of sexual reproduction (Welch—Gilman 1948).

The pycnidia are found embedded in the black stroma under the epidermis. Their size and shape greatly depend on the plant part they are formed on. They are somewhat wider on the stem, nearly spherical on the pods and spherical on the leaves. The size of the pycnidia is $82-225 \times 82-375$ μm on the pods and stem, and $120-180 \times 135-240$ μm on the leaves. Most of the pycnidia have a single cavity, though some have two or more cavities. Each cavity opens on to the surface through an ostiolum (Fig. 4).

The conidia are unicellular, hyaline, usually binucleate, linear-elliptical and generally biguttulate (Fig. 5). According to Sinclair—Shurtleff (1975) they are $4.9-9.8 \times 1.7-3.2$ μm in size. While measuring the conidia formed in the pycnidia of the stem the average size was found to be 7.4×3.2 μm, ranging from 6.0 to 9.1 μm in length and from 2.6 to 4.3 μm in width. The conidia reach the surface in the thick fluid filtering through the ostiolum.

The perithecia, which are seldom formed, are spherical, smaller than the pycnidia and slightly flattened at the base; they are $48-282 \times 185-346$ μm in size (Sinclair—Shurtleff 1975). On the perithecium a long tapering ostiolum is found; the perithecia are arranged singly in the black stroma, which is $60-142$ μm wide and emerges to a height of 1.5 mm.

In the cavities of the perithecium large numbers of elongated-clavate, eight-spored asci with slightly thickened tips are found (Fig. 6A). They are $35-51 \times 3.3-10$ μm in size.

The ascospores are hyaline, one-septate, elliptical, with rounded ends, somewhat coarctated at the partition wall, with two nuclei in each cell, and $9-13\times2-6$ μm in size (Fig. 6B). The small germ tubes of the spores usually protrude from or near the end of the cell (Fig. 6C).

Disease cycle and epidemiology

The sources of primary inoculum are the infected plant residues, the soil and the seed. On areas where the disease has not yet occurred imported seeds infected by *Diaporthe phaseolorum* var. *sojae* represent the most important source of inoculum. SZALAY (1976) observed damage in plant stands developed from imported seeds of the soybean varieties Clay, Merit and Altona.

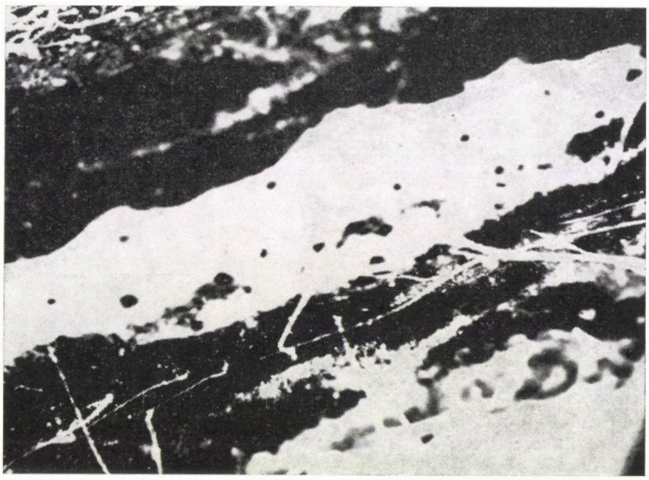

Fig. 2. Pycnidia may be formed in well defined lesions on the stem

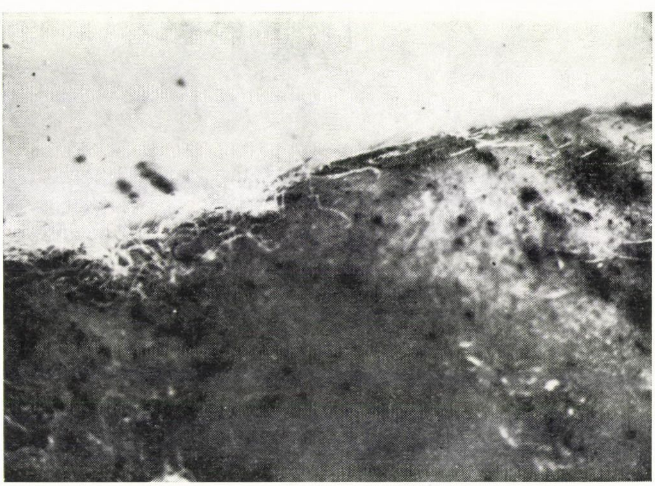

Fig. 3. Infected soybean pod with scattered pycnidia

In seeds stored under cool, dry conditions the fungus survives for two years. The mycelium penetrates the ovule and interlaces the cotyledon, radicle and plumule. The disease can spread from plants grown from infected seeds.

An over-dense stand of plants promotes the infection of the seeds.

In the first phase of plant development the active penetration of the fungus through the thin-walled portion of the cortex is restricted. Later, however, it may even penetrate the thick-walled tracheae, thus becoming systemic.

Diaporthe phaseolorum var. *sojae* is able to infect many plant species, including *Phaseolus vulgaris*, *Phaseolus limensis*, *Vigna unguiculata*, *Allium sativum*, *Lespedeza* ssp., *Lupinus* ssp., *Arachis hypogaea*, *Hibiscus esculentus*, *Allium cepa*, *Capsicum frutescens* and *Lycopersicon esculentum*.

Fig. 4. Phomopsis sojae pycnidium with ostiolum

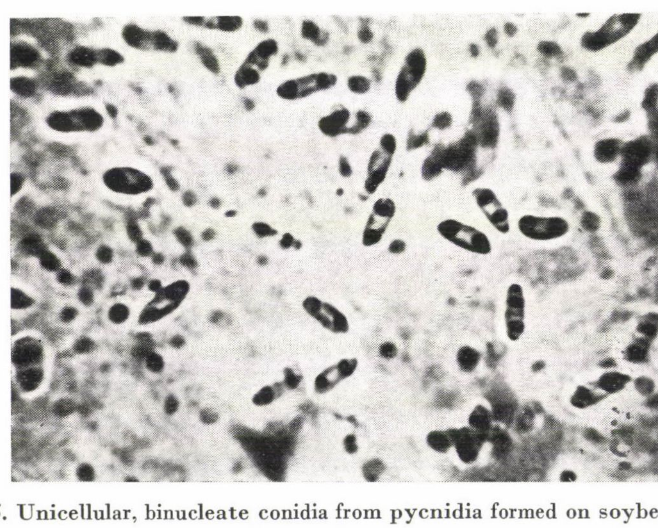

Fig. 5. Unicellular, binucleate conidia from pycnidia formed on soybean stem

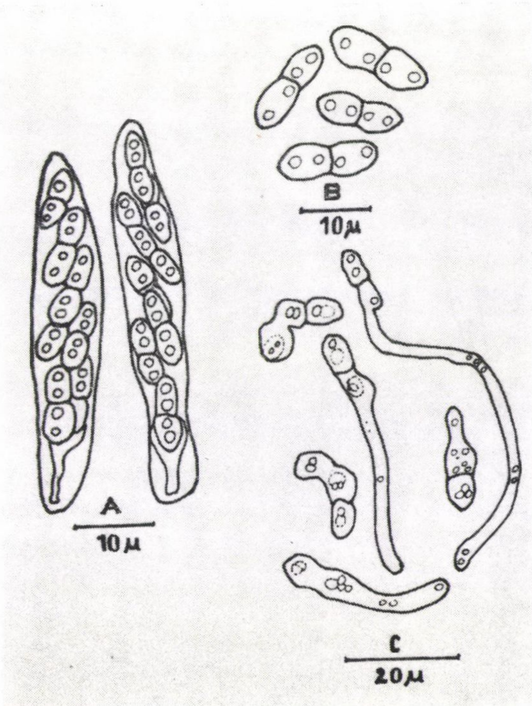

Fig. 6. A: eight-spore asci of *Diaporthe phaseolorum* var. ***sojae***; *B:* bicellular ascospores; *C:* germination of ascospores (after Lehman)

Possibility of growing the fungus in culture

While studying the ecological requirements of the pathogen three culture media were tested. The fungus displayed optimum growth and fructification on potato dextrose agar (pH 4.5). Modified Leonian agar culture media (with 10 ml "Nektár" medicinal beer or ground, hydrolysed, germinated barley substituted for malt extract — Kövics 1978) are also suitable, though in this case growth is slower and the pycnidia appear later. Light is required if pycnidia are to form (Sinclair—Shurtleff 1975).

The heat optimum of the pathogen was found to be 25°C. At this temperature the organization of the pycnidia begins on the 12th day under neon tube illumination, and on the 15th day in a dark thermostat. Information on the intensity of development at a series of temperatures is given in Fig. 7. At temperatures of 15—20°C the fungus is still able to develop and fructify, while at 5—10°C development is greatly retarded. At a temperature of 30°C the curve of development is stepwise, with alternating phases of growth and stagnation, then when the culture medium dries up the development stops completely. At 35°C the fungus no longer grows.

Possibilities of controlling the disease

Since the fungus may cause considerable losses owing to its high pathogenicity, the following factors should be taken into consideration in control projects:

1. Good quality, healthy seed should be used.
2. An optimum potassium supply results in reduced seed decay.

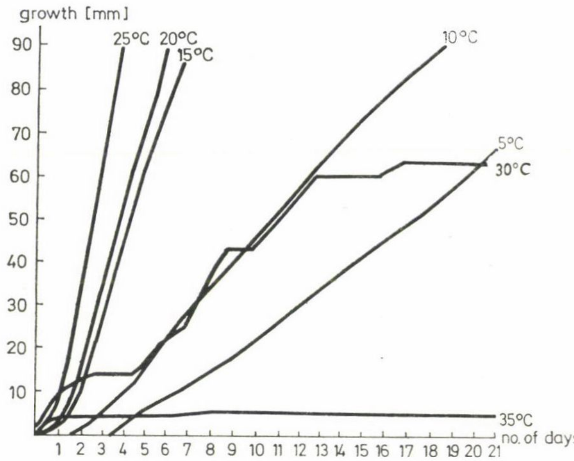

Fig. 7. Heat optimum diagram for *Diaporthe phaseolorum* var. *sojae*

3. Crop rotation; after harvest plant residues should be ploughed deep into the soil.
4. Spraying with fungicides should be applied at mid-flowering, then at the late pod stage to prevent pod and seed infection.
5. Varieties resistant to the pathogen should be grown (SINCLAIR—SHURTLEFF 1975).

In resistant varieties there is a lower extent of seed infection (WILCOX *et al.* 1974, SINCLAIR 1977).

Damage caused by delayed harvesting can be reduced by applying benomyl at mid-flowering and during seed formation (WALLA 1974, DE LOUCHE 1975, FOOR—SINCLAIR 1976, ILYAS *et al.* 1976).

In the case of seeds with or without symptoms, dressed with Thiram (TMTD), the development of *Phomopsis sojae* decreased, but the fungicide had a greater effect on fungi developing from symptom-free seeds than on those developing from seeds showing symptoms (HEPPERLY—SINCLAIR 1978).

When examining the toxicity of fungicides to N-fixing bacteria in laboratory experiments and field trials, KECSKÉS (1973) found that fungicides containing mercury and copper had the highest toxicity, while those containing thiram and captan only slightly inhibited these useful bacteria. CHAMBERLAIN—GRAY (1974) observed a 2—27% increase in germinative ability when infected seeds were dressed with captan and thiram. Fungicides containing benomyl, benomyl + captan, captan, bavistin and chloroneb were also found to be effective (GRAY—SINCLAIR 1970, ZINOVEV—BATALOVA 1976).

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Prepared at the Phytopathological Laboratory of the Research Centre for Agrobotany of the National Institute for Variety Testing, Tápiószele.

GY. KÖVICS

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COMBINING ABILITY OF F_1 ALFALFA MADE WITH CYTOPLASMIC MALE STERILITY

There are two ways in which alfalfa breeding endeavours to achieve yield increases:

1. by increasing the potential productivity;
2. by reducing losses caused by phytopathogens and by achieving better utilization due to more favourable quality components.

Hybrid production is typically a representative of the first method. Alfalfa F_1s which were 30—40% superior to the parents had already been produced by hand crossing in greenhouses by the 1940s. The greatest obstacle to mass reproduction was the impossibility of checking the parents: owing to a greater or lesser extent of self-pollination the yield of the new synthetic varieties hardly exceeded that of the earlier varieties, if at all.

The observation made by CARNAHAN—PEADEN (1967) was very remarkable. They pointed out that even with less than 10% self-pollination the progenies of two-clone alfalfa combinations gave significantly reduced yields. Controlled pollination was given an important role in breeding aimed at producing new varieties. There seemed to be several possibilities for the solution, namely:

a) self-incompatibility,

b) genic and

c) cytoplasmic male sterility.

Self-incompatibility in alfalfa is not always a guarantee of outcrossing, while the genic male sterility discovered by CHILDERS—MCLENNAN (1960) only made pollen control possible for the breeders' "domestic use", owing to the great expense of producing F_1s from cloned parents. Cytoplasmic male sterility provides a successful and theoretically simple method for the farm-scale production of hybrids. The first alfalfa hybrids were made commercially available in 1968 in the United States. The seed production technology for hybrid alfalfa was patented in 1971 by the Teweles Seed Co. The hybrids are theoretically superior to the synthetic varieties for the following reasons:

1. inbreeding, which is excluded in hybrids, may play a considerable role in producing grade I and II generations of synthetic varieties (particularly when there are only a few clone parents);

2. natural selection, which is not economically advantageous, does not exercise an unfavourable effect on the composition of the population;

3. non-additive gene effects also become utilizable in producing a variety through the propagation of special combinations (BUSBICE *et al.* 1972).

Apart from the peculiar male sterile transmission mechanism the parents of hybrids must have excellent combining ability. Pollen sterility represents something new in the combining ability tests too, as it makes crossing technically simpler, and operations such as alcoholic treatment and flag cutting become superfluous.

Contrasting views are to be found in the literature with respect to the size of the individual components of genetic variance in alfalfa.

TYSDAL *et al.* (1942) and BOLTON (1948) arrived at the conclusion that the heterosis effect observed in the experiments and the special combining ability make efforts at hybrid production worthwhile. In experiments carried out by KEHR—GARDNER (1960) and DUDLEY *et al.* (1969) on the alfalfa varieties Ranger and Cherokee, the non-additive genetic variance made up two-thirds of the total genetic variance.

Other authors (PEARSON 1958, WILCOX 1961, DOWNEY 1961, BINGHAM 1961) emphasize the importance of general combining ability. According to DUDLEY (1963), in the case of hand crossing without emasculation the effects of selfing were not taken into consideration, and the general combining ability was thus overestimated compared to the special combining ability. PEDERSEN—HILL (1972) studied the combining ability in cytoplasmic male sterile alfalfa. In a two-factor experiment arranged in a random block design they found all the genetic components of the green yield to be significant in the first year.

In the second year after planting the combining ability of hybrids made with cytoplasmic male sterility was not very great.

Experiments aimed at discovering clones with cytoplasmic-genic inheritance were started in Hungary at the end of the 1960s, first at Martonvásár, then under the guidance of Dr. Zoltán Bőjtös at Kompolt. A number of male sterile plants were crossed with fertile ones, and the F_1s were put in field trials, then subjected to cytological examination. One sterile plant proved to possess plasma genes inducing sterility besides the mendelizing chromosomal genes; in BC_2 the proportion of fertile plants was less than one-sixth (BŐJTÖS 1974).

In combining ability tests performed in 1974—1976 with six different male sterile clones (1 cytoplasmic, 3 genic, 1 self-incompatible and 1 morphological mutant with an exposed stigma) results were obtained which showed exactly the same tendency as those published by PEDERSEN—HILL (1972). In the second and third years the special combining ability, which primarily consists of non-additive effects, ceased to be an important source of genetic variance. The maternal (sterile) components of the general combining ability was always significant, while the paternal component was only significant in a few cases, so the productivity of the hybrids depended to a decisive extent on the right choice of sterile plants (NAGY 1979).

Parallel with the sterile clones a trial was set up with the parents included in the second stage of hybrid production (cms F_1 and the C-partner). The material of the experiment described above was composed of clones (sterile and fertile), while in the crosses described below F_1 hybrids from the same cms-clone but produced with different maintainers were used as mother plants, and varieties and lines as pollen parents.

Two trials were set up in 1974—1976 with three-way cross hybrids produced on the basis of cytoplasmic male sterility in order to study the genetic variance and its components. An account of these trials is given in the present paper.

Table 1

VA structure of split-plot design in the case of factorial coupling

Cause of variance (1)	DF	MQ	Statistical variance components (2)
All plots	rmf — 1		
Replications	r — 1		
Combinations	mf — 1		
C-partners	m — 1	MQ_M	$\sigma^2_{e_1} + f\sigma^2_{e_2} + r\sigma^2_{MF} + rf\sigma^2_M$
Error (between C — s)	(r — 1)(m — 1)	MQ_{e_2}	$\sigma^2_{e_1} + f\sigma^2_{e_2}$
F_1	f — 1	MQ_F	$\sigma^2_{e_1} + r\sigma^2_{MF} + rm\sigma^2_F$
$F_1 \times C$	(m — 1)(f — 1)	MQ_{MF}	$\sigma^2_{e_1} + r\sigma^2_{MF}$
Error (between F_1s within C)	m(r—1)(f—1)	MQ_{e_1}	$\sigma^2_{e_1}$

Signs and abbreviations:

σ^2_M = statistical variance components of GCA in pollen parents
σ^2_F = statistical variance components of GCA in seed parents
σ^2_{MF} = variance component of SCA
$\sigma^2_{e_1}$ and $\sigma^2_{e_2}$ = variance component of accidental environmental effect per plot

Seed for both experiments were produced by hand crossing in a greenhouse in the winter of 1973/74. The combination programme was prepared on the basis of Experiment II of COMSTOCK—ROBINSON (1952). Forty combinations (crosses of 5 F_1 and 8 pollen-parents) were included in the first experiment, and 36 combinations (6 F_1 and 6 pollen-parents) in the second experiment. The F_1s originated from the same cytoplasmic clone (A-1), which was crossed with various maintainers (B-3, B-4, B-7, B-9, B-11, B-14). The pollen-parents were varieties and strains obtained from the Agrobotanical Centre. The treatment combinations used in the experiments were composed according to a factorial combination scheme: the members of the maternal group were crossed one by one with those of the paternal group.

On the basis of previous information and owing to the need to select F_1s (or rather sterility maintainer clones, as only one cms-parent has been used so far) according to general combining ability, split-plots were used instead of a random block design.

The main plots contained the pollen parents and the sub-plots the cms F_1s. Due to internal replications this arrangement ensured a more reliable estimation of the maternal (sterile) general combining ability and of the special combining ability. The treatments in the experiment were randomized first by pollen-parents (main plots) then by mothers (sub-plots).

The plot size was 0.75 m^2, and the number of seed sown was 100/m. The green yield was evaluated per cutting, per year, and on the basis of results totalled over two or three years.

In the statistical evaluation (NAGY 1977) two components of error were calculated, representing the environmental effect in the phenotypic variance (Table 1).

In the first year each experiment was cut three times. In the year the experiment was set up the special combining ability (σ^2_{MF}), consisting mostly of non-additive effects, played an important role in shaping the productivity of the 76 three-way cross combinations, as shown by the variance analysis of the totalled crop results of 3 cuttings (Tables 2, 3, 4, 5). The almost identical rate of decrease in the statistical variance component (σ^2_{MF}) of the special combining ability in the course of three cuttings in both experiments (I: 0.0061—0.0016—0.0002; II: 0.0066—0.0010—0.0001) is noteworthy. The same was observed in combining ability studies made with various types of male sterile clones (cms, genic male sterility, self-incompatibility, morphological male sterility) where the corresponding values in the successive cuttings were: 477.2—294.5—13.9 (NAGY 1977).

Of the variations in general combining ability in the parents only that in the seed parent was significant in the first year. Genetic differences between the sterile F_1s can be demonstrated with significance at the $P = 5\%$, 1% or 0.1% levels on the basis of the average yield result of TC-progeny. The general combining ability of the pollen-parents (a total of 14 synthetic varieties and lines with different ecotypes) did not play any role in shaping the productivity of the experimental three-way cross combinations.

In the second year the paternal effect in Experiment I was statistically demonstrable in three of the 5 cuttings. The same can be said about the significance of special combining ability in the course of cutting. The difference between F_1s in general combining ability could be statistically proved in every case.

According to the variance analysis in Experiment II the genetic variation consisted decisively of maternal (F_1) additive effects, so in this experiment the better F_1s generally produced better progenies than those with poorer general combining ability. In the first two years of this experiment there were no outstandingly good or bad combinations. The genetic effects of the pollen-parents can be said to be identical within the limits of error.

In the third year the fodder yield of three-way cross combinations produced on the basis of cytoplasmic male sterility was shaped by the genetic effects characteristic of the previous year. In spite of the fact that the variance component of the special combining ability (σ^2_{MF}) was significant only for the first cutting in Experiment I and the fourth cutting in Experiment II, a significant genetic interaction was shown in the green yields of the third

Table 2

Statistical variance components of combining ability calculated from the green yield of TC alfalfa hybrids produced on the basis of cytoplasmic male sterility

Experiment I

Year	Cutting	Statistical variance components						
		σ^2_M	σ^2_F	σ^2_{MF}	$\sigma^2_{e_1}$	$\sigma^2_{e_2}$	σ^2_G	σ^2_P
1st	1st	0.0034	0.0097***	0.0061**	0.0310	0.0126	0.0192	0.0628
	2nd	0 (negative)	0.0023**	0.0016**	0.0090	0.0042	0.0039	0.0171
	3rd	0 (negative)	0.0006**	0.0002	0.0070	0.0022	0.0008	0.0100
Year total		0.0017	0.0223***	0.0152***	0.0780	0.0258	0.0392	0.1430
2nd	1st	0.07***	0.05*	0.41**	0.0407	0.0071	0.0541	0.1019
	2nd	0.0011	0.0037***	0.0000	0.0247	0.0038	0.0048	0.0333
	3rd	0.0020*	0.0055***	0.0023**	0.0126	0.0004	0.0098	0.0228
	4th	0.0022**	0.0066***	0.0022	0.0210	0.0004	0.0110	0.0324
	5th	0 (negative)	0.0022***	0.0007*	0.0052	0.0011	0.0029	0.0063
Year total		0.0096*	0.0572**	0.0520***	0.2056	0.0273	0.1188	0.3517
1st + 2nd year total		0.0360*	0.0701**	0.0995***	0.3114	0.0622	0.2056	0.5802
3rd	1st	0.0000	0.0113**	0.0057*	0.0495	0.0255	0.0170	0.0920
	2nd	0.0031**	0.0144***	0.0009	0.0183	0.0010	0.0184	0.0395
	3rd	0 (negative)	0.0033***	0.0001	0.0250	0.0208	0.0034	0.0492
	4th	0.0023*	0.0012**	0.0015	0.0200	0.0016	0.0050	0.0266
Year total		0.0020	0.0842***	0.0314*	0.2249	0.0866	0.1176	0.4291
1st + 2nd + 3rd year total		0.0676	0.2643***	0.2320***	0.8200	0.1680	0.5639	1.5519

*, **, *** Significant at the 5, 1 and 0.1% levels, respectively

Legends used in the table:

σ^2_M = statistical variance component of general combining ability in the pollen-parent
σ^2_F = statistical variance component of general combining ability in the seed-parent
σ^2_{MF} = statistical variance component of specific combining ability
σ^2_G = variance component of genotypic variance
σ^2_P = variance component of phenotypic variance
$\sigma^2_{e_1}$ and $\sigma^2_{e_2}$ = statistical variance components of accidental environmental effect per plot

Table 3

Statistical variance components of combining ability on the basis of green yield production by TC progenies of alfalfa

Experiment II

Year	Cutting	Statistical variance components						
		σ^2_M	σ^2_F	σ^2_{MF}	$\sigma^2_{e_1}$	$\sigma^2_{e_2}$	σ^2_G	σ^2_P
1st	1st	0 (negative)	0.0062**	0.0066**	0.0245	0.0018	0.0128	0.0391
	2nd	0.0002	0.0031***	0.0010*	0.0017	0.0015	0.0043	0.0134
	3nd	0 (negative)	0.0004*	0.0001	0.0072	0.0017	0.0005	0.0094
Year total		0 (negative)	0.0081*	0.0159***	0.0511	0.0047	0.0240	0.0798
2nd	1st	0.0086*	0.0033	0 (negative)	0.1335	0 (negative)	0.0119	0.1454
	2nd	0 (negative)	0.0024**	0.0003	0.0288	0 (negative)	0.0027	0.0315
	3rd	0.0007	0.0043***	0.0015*	0.0114	0.0046	0.0065	0.0225
	4th	0.0021	0.0024***	0.0012	0.0157	0.0069	0.0057	0.0283
	5th	0.0005	0.0005**	0 (negative)	0.0064	0.0027	0.0010	0.0101
Year total		0 (negative)	0.0436***	0.0000	0.3598	0.0161	0.0436	0.4195
1st + 2nd year total		0 (negative)	0.0344**	0.0416	0.5100	0.0302	0.0760	0.6162
3rd	1st	0 (negative)	0.0085***	0.0029	0.0386	0.0202	0.0114	0.0702
	2nd	0.0038*	0.0079***	0.0011	0.0125	0.0049	0.0128	0.0302
	3rd	0 (negative)	0.0044***	0 (negative)	0.0217	0.0089	0.0044	0.0306
	4th	0.0002	0.0009	0.0048*	0 (negative)	0.0189	0.0059	0.0248
Year total		0 (negative)	0.0688***	0.0293*	0.1755	0.558	0.0981	0.3294
1st + 2nd + 3rd year total		0 (negative)	0.2047**	0.1574*	0.9534	0.0062	0.3621	1.3217

*,**,*** Significant at the 5, 1 and 0.1% levels, respectively
The legends used in the Table are the same as in Experiment I

Table 4

Combining ability (SCA and GCA) values calculated on the basis of average green yields over three years for TC progenies (SCA values are given in the body of the Table)

Experiment I

cms F_1s \ C-partners		31	62	68	79	83	87	88	92	GCA F_1
F_1	103	0.31	−0.33	0.09	0.89	−1.51	0.06	−0.18	0.44	0.09
F_1	107	0.07	0.32	−0.05	−0.71	0.61	0.46	−0.58	−0.15	−0.17
F_1	109	0.11	0.58	−1.38	0.36	−0.29	0.30	0.31	−0.02	0.56
F_1	111	−0.44	−0.42	0.46	−0.21	0.22	−0.26	0.44	0.17	−0.86
F_1	114	−0.10	−0.20	−0.86	−0.46	0.92	−0.62	−0.02	−0.41	0.41
GCA C-partners		−0.26	−0.62	0.61	−0.20	0.19	−0.06	0.55	0.17	

Table 5

SCA values (in the body of the Table) and GCA values calculated from green yield averages over three years for TC progenies made with cytoplasmic male sterility

Experiment II

cms F_1s \ C-partners		81	84	85	86	90	91	GCA F_1
F_1	103	−0.04	0.96	−0.67	−0.21	0.39	−0.44	−0.02
F_1	104	−1.20	0.11	−0.10	0.24	0.02	0.87	−0.30
F_1	107	0.64	0.18	0.14	−0.80	0.18	−0.34	−0.26
F_1	109	0.33	−0.54	0.93	−0.21	0.82	−0.11	0.72
F_1	111	−0.14	−0.15	−0.41	0.57	−0.17	0.29	−0.62
F_1	114	0.45	−0.55	0.10	−0.04	0.37	−0.29	0.49
GCA C-partners		−0.02	−0.09	−0.04	0.38	−0.15	−0.07	

year. The role of the fertile pollen-parents in shaping the productivity of the progeny was further reduced in Experiment II as well, so the variance analysis of the totalled green yield data of the third year confirms an earlier opinion (Pedersen—Hill 1972, Nagy 1977), namely, that the genetic effect of pollen-parents cannot be demonstrated in the productivity of the progeny.

It was only for two cuttings that the genetic differences between the cms-F_1s were not significant in the 34 VA, which proves the steady role of the general combining ability of the seed parent (maternal additive gene effects) in the case of the 76 three-way cross (TC) progeny produced.

As far as life performance is concerned, two genetic effects (maternal additive and genetic interactions) were statistically demonstrable. In Experiment I both were significant at the 99.9% level, while in Experiment II the σ_F^2, the general combining ability (GCA) of the seed parent, was higher ($P = 1\%$).

The data were evaluated according to the model constructed for the diploids. Alfalfa is an autotetraploid plant. A number of papers have recently been published to prove that in the case of monogenic qualitative characters (e.g. golden cotyledon, STANFORD 1951; exposed stigma mutation, MARCUS—WILSIE 1957) the alfalfa plant shows tetraploid segregation ratios. Owing to the complex polygenic nature of the quantitative characters, the elaboration of a tetra-allel analysis which will register tri- and tetra-allel interactions, and which is suitable for practical purposes, is an important task facing theoretical geneticists and statisticians.

The combining ability values calculated by the two models consist of not completely identical genetic effects; in the case of tetraploids the general combining ability determined using the diploid model, which shows exclusively additive genetic variation, also contains other effects (digenic interactions, additive × dominance, dominance × dominance), so the general combining ability is higher than the additive genetic variation (DUDLEY 1963).

Selecting for productivity is made still more difficult by the fact that genotypic variation is much smaller than phenotypic variation. Owing to the additive genetic variation, which is actually even lower than shown by the diploid model, and to the great environmental effect, the yield of synthetic varieties produced with the selected parents only exceeds that of the control, an old local variety in Hungary (Nagyszénási) to a minimum extent (by 2—3%).

Special combining ability (SCA), which decreased with the successive cuttings in the first year, can be associated with the seed effect. PEDERSEN—HILL (1972) found a significant positive correlation between the first cutting and the seed size. CARNAHAN (1963) demonstrated a relationship between the area of the first foliage leaf, the seedling weight at the age of 4 weeks and the seed yield. The more intensive initial development resulting from larger seeds may be due to double pollination.

Hybrid research was particularly successful with those plant species where the original pollination system of the plant was changed, then restored. In the case of hybrid maize the originally outcrossing plant was made a self-pollinator, inbred lines were produced, then after adequate selection outcrossing was carried out again (hybrid production). In the case of alfalfa there are no inbred hybrids as yet. The lengthy procedure of inbreeding is complicated by several factors (lethality, self-incompatibility). Owing to the tetraploid character, the best method of studying the specific combining ability and of producing hybrids with inbred parents will be double crossing.

The following theory is offered as an explanation of the less important genetic role of the pollen-parents (NAGY 1979).

Alfalfa is a facultative allogamous species. It can be assumed that the cytoplasmic male sterile plant included in the experiments was a heterozygote, or became one when crossed with the maintainer. In the combining ability tests the F_1s (as seed parents) and the pollinators (the third partner is usually a variety or line) were used. The sterile material in the present study can be regarded as consisting of heterozygotes and partial heterozygotes, since with tetraploids the inbreeding coefficient of S_5 is fairly low even when there is only one locus ($F = 0.598$ compared to 0.969 with diploids), and each yield component, particularly the green yield, is controlled by several genes.

The heterogeneity of the heterozygous sterile parents is only slightly increased by the pollen-parents, which is probably also a heterozygous plant, if at all. This is why there is no genetic difference between the pollen-parents, and why their GCA variation is not significant.

Let us now suppose that we have a homozygous (aaaa, monogenic in the Demarly-model, nulliplex in the Hill-model) sterile plant. In this case the genotype of the F_1 depends on the genotypic state of the pollen-parent. If, for example, the pollen-parent is also a monogenic (bbbb) plant, the progeny will be duplex (aabb); if it is trigenic (bbcd), the progeny will have duplex or triplex genotypes, i.e. the role of the pollen-parent will be decisive in the performance of the hybrids.

In the present case, and also in combining ability studies on the alfalfa hybrids so far produced, the performance of progenies derived by crossing heterozygous pollen-parents depended on how close the sterile parents (seed parents) were to the homo- or heterozygous state. It was therefore the genotype of the sterile parents that decided the performance of the progeny.

Considering the data obtained, the tasks facing hybrid alfalfa research can be summarized as follows:

a) to make it possible to select for the general combining ability of seed parents, by producing cms-translocation forms;

b) to produce cms-F_1s which are more productive than the present ones, using new maintainers;

c) to produce new C-partners by recurrent selection using the best pollen-parents (on the basis of SCA with the best cms-F_1); and

d) to produce inbred hybrids.

With reference to the split-plot design, this can be said to be advantageous in every case when previous information is available on the non-identical genetic importance of the seed — and pollen-parents.

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*

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B. Nagy

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MAIZE INBRED LINES, SINGLE AND DOUBLE CROSSES AS AFFECTED BY COLD WAVE AND PLANT GROWTH REGULATOR

Good seed germination and a good stand are essential in maize for the production of maximum yields. Poor stands of maize are most frequent when planting is followed by a period of cold wet weather which is suitable for the development of pathogens at the expense of the seed or young seedlings. It has been observed that different seed lots of maize, with equally favourable laboratory germination, may give very different field stands when grown in comparative trials under adverse conditions of cold, wet weather. It seems important to study the extent to which the environment and heredity are responsible for these differences.

According to PENDLETON (1965), planting maize earlier than the traditional planting dates should give the following advantages: (a) Shorter plants with lower ears and better standing ability. (b) Drier grain allowing earlier harvest. (c) Pollination and grain-filling during long light-days. (d) Pollination prior to the hot, dry days of late harvest and (e) reduction in soil water evaporation. The production of maximum yields at early planting dates needs materials which are tolerant to unfavourable climatic conditions.

It is well known that maize has a tremendous variability in its ability to germinate at low temperatures (PINNELL 1949, LUDWIG *et al.* 1957, GUPTA—KOVÁCS 1974, 1975). Data have also been presented by a few workers on the ability of maize to grow at temperatures below optimum or on the growth of seedlings under cool natural conditions (PESEV 1969, GROGAN 1970, MOCK—EBERHART 1972, MOCK—SKRDLA 1978).

The study consisted of two double crosses developed at Martonvásár, namely MvDc 460 and MvDc 520, single crosses B 125 × B 18/4, Beo3b × N6, 156 × N6 and C5 × 014, and four inbred lines B 125, B 18/4, Beo3b and 014. This means that 10 different genotypes were used

Table 1

Effect of cold wave and plant growth regulator on plant height
(cm)

Genotypes	Control						Low temperature treatment			
	3		4		5		4		5	
	week old plants									
	Ø	Sz 28	Ø	Sz 28	Ø	Sz 28	Ø	Sz 28	Ø	Sz 28
Inbred lines										
B 125	78.0	72.0	97.0	88.7	92.0	89.0	81.7	56.3	79.3	62.0
B 18/4	55.0	56.0	70.0	61.7	76.2	68.4	62.7	60.3	72.0	64.3
Beo3b	47.3	50.7	65.7	67.3	69.2	68.4	68.3	58.3	70.3	62.4
014	56.3	54.7	78.0	76.7	79.4	78.4	61.7	61.0	69.3	65.2
Single crosses										
B 125×B 18/4	69.0	80.3	78.8	94.0	82.3	90.0	83.0	85.0	80.4	86.0
Beo3b×N6	78.7	70.7	97.3	86.7	101.2	89.2	81.3	81.7	89.4	88.2
156×N6	68.0	77.7	90.0	91.7	99.8	92.3	78.7	80.0	81.2	83.4
C5×014	76.3	60.0	94.7	92.7	98.3	94.2	85.0	77.7	89.4	82.3
Double crosses										
B 125×B 18/4× Beo3b×N6 (MvDc 460)	62.7	77.3	89.7	93.0	93.4	91.0	80.7	87.3	86.5	84.2
156×N6×C5×014 (MvDc 520)	69.7	73.0	93.7	94.0	102.3	93.2	80.7	76.0	88.6	83.2
Means										
Inbred lines	59.2	58.4	77.6	73.6	79.2	76.1	68.5	59.0	72.7	63.5
Single crosses	73.0	72.2	90.2	91.3	95.4	91.4	82.0	81.1	85.1	85.0
Double crosses	66.2	75.2	91.7	93.5	97.9	92.1	80.7	81.7	87.6	83.7
General mean	66.1	68.7	86.5	86.1	90.8	86.5	77.1	73.9	81.8	77.4
L.S.D. 5%										
Genotypes	7.4		6.5		12.3		8.6		10.1	
General mean	3.3		2.9		5.9		3.9		5.3	

in the experiments. Seeds from the different genotypes were germinated on moist filter paper sheets in a germination incubator and planted in 10 cm plastic pots filled with three parts loam soil with high organic matter and one part sand. 38 pots were planted for every genotype. The pots were placed in a growth chamber at 25°C day temperature and 12°C at night for five weeks, and this chamber was considered as the control. After the third week ten seedlings from each genotype were taken to another chamber which was named the cold chamber, with 12°C day temperature and 3°C at night for one week, after which five seedlings from each genotype were returned to the growth chamber and the other five seedlings were used for the analysis of the morphological data and for chemical analysis. Sz 28 was used as plant growth regulator at a concentration of 500 ppm and maize seedlings were sprayed three times a week with a hand sprayer. The aim of the experiment was to study the effect of a cold wave on the characters of different maize genotypes, and the relation between Sz 28 as plant growth regulator and the tolerance of the genotypes to cold wave conditions. A sample of five seedlings from each genotype was taken on three occasions from the control and on two occasions from the cold wave treatment for the determination of morphological characters, namely plant height cm (until top of the leaves), number of leaves/plant, percentage of green leaves to total leaves/plant, fresh weight g/plant. Chemical analysis was done for chlorophyll content *a* and *b* mg/g fresh weight, nucleic acid P-32 cpm/g fresh weight, $^{14}CO_2$.

The experiment was conducted in the phytotron of the Agricultural Research Institute of the Hungarian Academy of Sciences at Martonvásár. For the chlorophyll analysis and the results obtained the authors are gratefully indebted to Dr. Márta Dévay and her staff. Many thanks are also due to Sándor Rajki, Director of the Institute and to Dr. István Kovács, head of the maize breeding department for their valuable assistance during this work.

The effect of plant growth regulator and cold wave on maize plant height is presented in Table 1.

Generally, it is evident that spraying with Sz 28 had no clear effect on plant height as compared with the control. The results also showed that a significant difference was observed between the inbreds and the hybrids. Also, the genotype of the hybrid and cold wave treatment affect the reaction of young maize seedlings to cool weather in a significantly different manner.

Table 2

Effect of cold wave and plant growth regulator on number of leaves/plant

Genotypes	Control						Low temperature treatment			
	3		4		5		4		5	
	week old plants									
	Ø	Sz 28	Ø	Sz 28	Ø	Sz 28	Ø	Sz 28	Ø	Sz 28
Inbred lines										
B 125	7.3	6.7	7.7	7.3	7.5	7.4	7.3	5.7	7.4	7.2
B 18/4	6.0	6.7	7.3	7.0	7.4	7.5	7.0	6.3	7.2	7.4
Beo3b	5.0	6.0	7.0	7.0	7.2	7.4	7.0	6.3	7.2	7.2
014	6.0	7.0	7.3	7.3	7.5	7.5	7.0	7.0	7.2	7.4
Single crosses										
B 125 × B 18/4	6.7	6.7	7.7	7.0	8.0	7.9	7.0	7.0	7.4	7.5
Beo3b × N6	7.0	6.7	7.7	7.0	8.4	8.2	7.0	7.3	7.8	7.6
156 × N6	7.0	7.3	7.3	7.3	8.6	8.4	7.3	7.7	7.8	7.8
C5 × 14	6.7	6.0	7.3	7.7	8.4	8.4	7.0	7.3	7.6	7.8
Double crosses										
B 125 × B 18/4 × Beo3b × N6 (MvDc 460)	6.3	7.0	7.3	7.7	9.2	9.0	7.0	7.7	7.8	7.6
156 × N6 × C5 × 014 (MvDc 520)	6.7	6.7	7.7	7.7	9.4	8.9	7.3	7.0	8.0	7.9
Means										
Inbred lines	6.1	6.6	7.3	7.2	7.4	7.5	7.1	6.3	7.3	7.3
Single crosses	6.9	6.7	7.5	7.3	8.4	8.2	7.1	7.3	7.7	7.7
Double crosses	6.5	6.9	7.5	7.7	9.3	9.0	7.2	7.2	7.4	7.8
General mean	6.5	6.7	7.4	7.4	8.4	8.2	7.1	7.0	7.6	7.6
L.S.D. 5%										
Genotypes	0.41		0.82		1.10		0.46		0.63	
General mean	0.30		0.58		0.82		0.20		0.45	

The results in Table 2 show the same trend. It will be seen in Table 3 that the cold wave affected seedling growth, expressed as

$$\%\text{ green leaves/plant} = \frac{\text{number of green leaves/plant}}{\text{total number of leaves/plant}},$$

in both the single and double crosses in comparison with the inbred lines. On the other hand, spraying with Sz 28 had no effect in increasing the ability of the plant to protect its leaves from drying.

Treatment of seedlings with a cold wave had the worst effect on the growth of young seedlings, as demonstrated by their fresh weight—(Table 4).

The effect of regulator and cold wave treatment on chlorophyll content is shown in Table 5 and Fig. 1. It was observed that the use of Sz 28 as plant growth regulator increased chlorophyll *a* and *b* as compared with the control. Total chlorophyll decreased with increasing plant age. Also, the chlorophyll level decreased when the maize seedlings were treated with a cold wave.

Mean observations over the various genotypes showed that the levels of chlorophyll *a* and *b* were 0.63, 0.36, 0.59 and 0.35 after the fourth week for the control plants, and 0.35, 0.21, 0.40 and 0.26 after the fourth week for the cold wave treated plants.

Table 3

Effect of cold wave and plant growth regulator on % green leaves/plant

Genotypes	Low temperature treatment 4-week old plants	
	Ø	Sz 28
Inbred lines		
B 125	100	100
B 18/4	100	100
Beo3b	100	100
014	100	100
Single crosses		
B 125 × B 18/4	42.9	58.9
Beo3b × N6	68.5	51.9
156 × N6	71.4	58.9
C5 × 014	77.1	57.1
Double crosses		
B 125 × B 18/4 × Beo3b × N6 (MvDc 460)	77.1	57.1
156 × N6 × C5 × 014 (MvDc 520)	68.5	47.1
Means		
Inbreds	100	100
Single crosses	64.9	56.7
Double crosses	72.8	52.1
General means	79.2	69.6

Table 4

Effect of cold wave and plant growth regulator on fresh weight/plant g

Genotypes	Control						Low temperature treatment			
	3		4		5		4		5	
	week old plants									
	Ø	Sz 28	Ø	Sz 28	Ø	Sz 28	Ø	Sz 28	Ø	Sz 28
Inbred lines										
B 125	12	13	32	32	45	26	26	14	35	37
B 18/4	8	7	28	21	29	24	13	19	30	34
Beo3b	10	18	16	17	20	25	13	16	22	37
014	14	13	30	40	36	25	16	22	31	33
Single crosses										
B 125 × B 18/4	14	18	36	46	56	42	28	35	39	48
Beo3b × N6	10	11	32	35	45	48	22	18	33	37
156 × N6	6	3	33	40	39	44	29	23	38	41
C5 × 014	13	11	17	33	39	35	19	37	32	37
Double crosses										
B 125 × B 18/4 × Beo3b (MvDc 460)	16	9	39	40	37	38	20	29	36	46
156 × N6 × C5 × 014 (MvDc 520)	15	15	36	31	49	41	20	28	35	37
Means										
Inbreds	11.00	12.75	26.50	27.50	32.50	25.00	17.00	17.75	29.50	32.25
Single crosses	10.75	10.75	29.50	38.50	44.75	42.25	24.50	28.29	35.50	40.75
Double crosses	15.50	12.00	37.50	35.50	43.00	39.50	20.00	28.50	35.50	41.50
General mean	12.41	11.83	31.16	33.83	40.08	35.58	20.50	24.83	33.50	39.16
L.S.D. 5%										
Genotypes	—		—		15.51		—		6.5	
General mean	—		—		6.96		—		2.9	

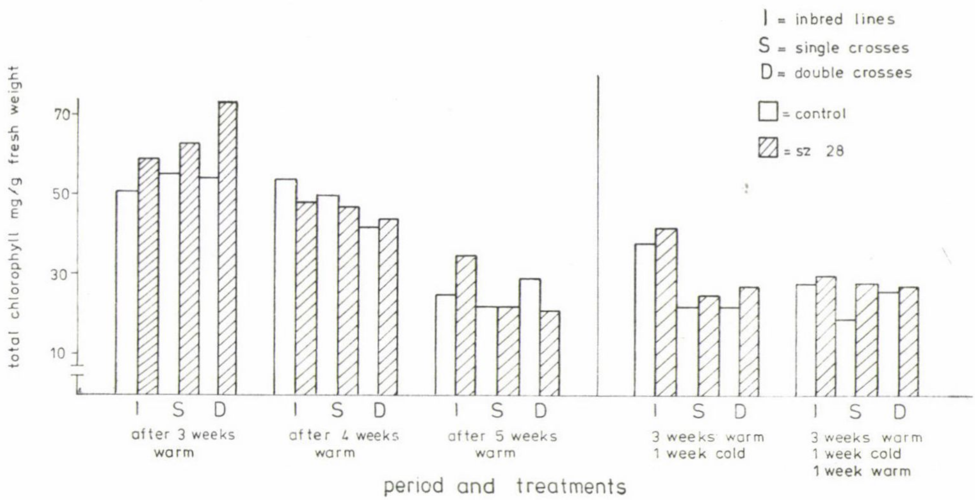

Fig. 1. Effect of periods, genotypes, cold wawe and regulator on the total chlorophyll content

The difference between the control and cold wave treated plants after the fifth week was less, because the seedlings in the cold wave treatment were treated after the cold wave by another warm wave, in other words, maize seedlings were able to regenerate their chlorophyll content if a warm temperature was applied after the cold wave.

It will be seen that the chlorophyll level in seedlings which were treated with a cold wave was correlated with the % green leaves/plant. The total chlorophyll in the cold wave treated plants after the fourth week was 0.78, 0.44 and 0.46 mg/g fresh weight for untreated seedlings and 0.85, 0.59 and 0.54 for those treated with Sz 28. On the other hand, the % green leaves for the same genotypes and treatments was 100, 64.9 and 72.8 and 100, 56.7 and 52.1 respectively (Table 3).

Generally, it was observed from Table 6 that in many cases the application of Sz 28 as plant growth regulator increased the nucleic acid P-32 content in comparison with the control. Also, the nucleic acid P-32 content differed between the studied genotypes and groups; it seems that the content was larger in the hybrids than in the parents.

It is clear from the Table that seedlings treated with Sz 28 were more active, especially in $^{14}CO_2$, and the rate of $^{14}CO_2$ in the hybrids increased compared to the inbred lines. From Table 7 a higher positive correlation was obtained between the total chlorophyll content and the nucleic acid P-32 during the five periods studied.

Table 5a

Effect of cold wave and plant growth regulator on chlorophyll a *and* b *content mg/g fresh weight*

Genotypes	Control											
	3				4				5			
	week-old plants											
	Ø		Sz 28		Ø		Sz 28		Ø		Sz 28	
	a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
Inbred lines												
B 125	0.86	0.43	0.66	0.31	0.78	0.42	0.47	0.32	0.30	0.11	0.51	0.18
B 18/4	0.72	0.35	0.73	0.37	0.68	0.39	0.67	0.44	0.31	0.10	0.54	0.21
Beo3b	0.91	0.47	1.12	0.55	0.69	0.41	0.69	0.49	0.49	0.19	0.49	0.19
014	0.70	0.36	0.64	0.31	0.61	0.32	0.48	0.27	0.34	0.13	0.55	0.18
Single crosses												
B 125 × B 18/4	0.63	0.31	0.86	0.45	0.53	0.29	0.44	0.25	0.35	0.13	0.35	0.13
Beo3b × N6	0.91	0.49	0.80	0.44	0.51	0.28	0.64	0.36	0.27	0.12	0.43	0.19
156 × N6	0.72	0.40	0.83	0.42	0.56	0.30	0.67	0.37	0.32	0.14	0.29	0.13
C5 × 014	0.64	0.33	0.90	0.41	0.92	0.57	0.62	0.35	0.31	0.13	0.18	0.08
Double crosses												
B 125 × B 18/4 × Beo3b × N6 (MvDc 460)	0.76	0.44	0.84	0.46	0.48	0.27	0.63	0.35	0.39	0.15	0.21	0.09
156 × N6 × C5 × 014 (MvDc 520)	0.58	0.29	0.97	0.46	0.66	0.38	0.55	0.30	0.43	0.19	0.37	0.16
Means												
Inbreds	0.80	0.40	0.79	0.39	0.69	0.39	0.58	0.38	0.36	0.13	0.52	0.19
Single crosses	0.73	0.38	0.85	0.43	0.63	0.36	0.59	0.33	0.32	0.13	0.31	0.13
Double crosses	0.67	0.37	0.91	0.46	0.57	0.33	0.59	0.33	0.41	0.17	0.29	0.13
General mean	0.73	0.38	0.85	0.43	0.63	0.36	0.59	0.35	0.36	0.14	0.37	0.15

Table 5b

Effect of cold wave and plant growth regulators on chlorophyll a *and* b *content mg/g fresh weight*

Genotypes	Low temperature treatment							
	4				5			
	week-old plants							
	Ø		Sz 28		Ø		Sz 28	
	a	*b*	*a*	*b*	*a*	*b*	*a*	*b*
Inbred lines								
B 125	0.65	0.36	0.62	0.34	0.31	0.13	0.41	0.16
B 18/4	0.46	0.30	0.56	0.32	0.46	0.20	0.39	0.15
Beo3b	0.32	0.18	0.63	0.35	0.42	0.20	0.51	0.28
014	0.53	0.31	0.34	0.21	0.42	0.18	0.31	0.17
Single crosses								
B 125 × B 18/4	0.13	0.08	0.31	0.19	0.16	0.05	0.30	0.11
Beo3b × N6	0.35	0.23	0.28	0.16	0.46	0.18	0.78	0.32
156 × N6	0.25	0.15	0.26	0.13	0.17	0.09	0.32	0.14
C5 × 014	0.35	0.21	0.43	0.26	0.27	0.12	0.22	0.09
Double crosses								
B 125 × B 18/4 × Beo3b × N6 (MvDc 460)	0.33	0.20	0.35	0.19	0.31	0.13	0.43	0.19
156 × N6 × C5 × 014 (MvDc 520)	0.24	0.14	0.35	0.19	0.39	0.19	0.29	0.16
Means								
Inbreds	0.49	0.29	0.54	0.31	0.40	0.18	0.41	0.19
Single crosses	0.27	0.17	0.32	0.27	0.27	0.11	0.41	0.17
Double crosses	0.29	0.17	0.35	0.19	0.35	0.16	0.36	0.18
General mean	0.35	0.21	0.40	0.26	0.34	0.15	0.39	0.18

The resistance of plants to extremes of temperature and moisture cannot be understood without adequate methods of measuring these properties. Such measurements must be not only quantitative but also absolute, rather than merely relative, for this permits the comparison of the resistances of different plants determined by different investigators.

The climatic factor which shows the worst effect on the genotype is temperature, particularly low temperature. At temperatures only slightly below the optimum, growth may stop or become abnormal (Evans 1963).

Wide variations have been found among maize lines for germination below 10°C and the rate of seedling growth at 13 to 16°C (Grogan 1970). Mishustina (1969) observed that non-cold resistant maize hybrids have reduced contents of chlorophylls *a* and *b* at 2 to 6°C. These findings are in good agreement with the results obtained here. Likewise, genotypic differences have been observed in tolerance of low temperatures during the early period of the maize growing season (Luksa 1967, Bojarczuk 1972, Gerasimov 1973, Hussein 1981). There was a close relation between the harmful effect of cold wave treatment and the growth of the different genotypes. The utilization of a cold wave retarded plant height, number of leaves, % green leaves, fresh weight and the chemical components of maize. These results were in line with those of Tatum–Zuber (1943), Gupta–Kovács (1974, 1975) and Jenkins–Roffey (1974).

Table 6a

Effect of cold wave and plant growth regulator on nucleic acid and CO_2 activity

Genotypes	Control						Low temperature treatment			
	3		4		5		4		5	
	week-old plants									
	nucl. acid P-32 cpm/g	$^{14}CO_2$ $\mu ci/g$	nucl. acid P-32 cpm/g	$^{14}CO_2$ $\mu ci/g$	nucl. acid P-32 cpm/g	$^{14}CO_2$ $\mu ci/g$	nucl. acid P-32 cpm/g	$^{14}CO_2$ $\mu ci/g$	nucl. acid P-32 cpm/g	$^{14}CO_2$ $\mu ci/g$
Ø										
Inbred lines										
B 125	57.6	1.17	117.4	0.72	220.7	4.51	187.6	0.87	131.3	2.51
B 18/4	67.8	1.26	121.9	0.87	209.3	4.13	166.2	0.75	162.6	3.15
Beo3b	78.2	1.48	216.3	1.09	251.4	5.10	174.5	0.64	175.7	3.40
014	58.2	1.19	246.8	1.28	347.2	6.79	190.4	0.81	128.0	2.21
Single crosses										
B 125 × B 18/4	46.2	1.02	137.4	0.96	932.1	6.57	157.3	0.85	222.5	4.40
Beo3b × N6	51.0	0.96	381.0	2.31	915.1	17.61	170.9	0.63	190.1	3.91
156 × N6	48.7	0.92	338.2	2.09	896.1	18.07	165.3	0.58	181.9	3.58
C5 × 014	45.3	0.85	369.7	2.18	830.2	17.15	196.2	0.87	214.3	4.17
Double crosses										
B 125 × B 18/4 × Beo3b × N6 (Mv 460)	41.3	0.81	432.1	2.97	757.4	15.23	214.0	0.96	238.2	4.58
156 × N6 × C5 × 014 (Mv 520)	40.1	0.76	517.1	3.81	978.4	21.14	105.2	0.43	246.1	4.93

The application of Sz 28 as a plant growth regulator increased the chlorophyll content in the plant organs. However, no difference was obtained in the ability of the seedlings to protect themselves from the cold wave.

Generally it was evident that maize hybrids were more sensitive to cold temperatures than inbred lines. Total chlorophyll content and % green leaves for the inbred lines was higher than for single or double crosses when a cold temperature was used. This may be attributed to the difference between the inbred lines and the hybrids in leaf cell number and size, water content, and stomata number and size.

*

Prepared at the Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvásár; Isotope Institute of the Hungarian Academy of Sciences, Budapest.

T. A. Hussein, B. I. Pozsár

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Table 6b

Effect of cold wave and plant growth regulator on nucleic acid and CO_2 activity

Genotypes	Control						Low temperature treatment			
	3		4		5		4		5	
	week-old plants									
	nucl. acid P-32 cpm/g	$^{14}CO_2$ μci/g	nucl. acid P-32 cpm/g	$^{14}CO_2$ μci/g	nucl. acid P-32 cpm/g	$^{14}CO_2$ μci/g	nucl. acid P-32 cpm/g	$^{14}CO_2$ μci/g	nucl. acid P-32 cpm/g	$^{14}CO_2$ μci/g
Sz 28										
Inbred lines										
B 125	71.4	—	56.2	0.31	362.0	7.14	62.1	0.40	116.3	2.20
B 18/4	68.2	—	63.4	0.44	417.3	8.20	67.8	0.45	109.4	1.98
Beo3b	61.3	—	51.8	0.34	315.4	6.08	47.6	0.27	121.6	2.45
014	70.9	—	69.7	0.58	425.0	8.53	65.4	0.45	137.4	2.61
Single crosses										
B 125×B 18/4	80.2	—	51.9	0.34	471.2	9.36	51.3	0.32	261.2	4.87
Beo3b×N6	72.7	—	65.7	0.43	480.4	9.74	342.7	2.16	218.0	4.02
156×N6	84.2	—	76.3	0.56	352.3	7.02	417.0	3.05	281.3	5.14
C5×014	52.7	—	96.2	0.87	327.0	6.56	335.9	2.08	305.6	6.01
Double crosses										
B 125×B 18/4× Beo3b×N6 (Mv 460)	58.1	—	71.8	0.53	450.9	9.64	356.1	2.11	294.3	5.87
156×N6×C5× 014 (Mv 520)	61.3	—	84.3	0.62	351.0	7.15	379.6	2.34	216.7	7.23
Means Ø										
Inbred lines	65.5	1.28	175.6	0.99	257.2	5.13	179.7	0.77	149.4	2.82
Single crosses	47.8	0.94	306.6	1.89	893.4	14.85	172.4	0.73	202.2	4.02
Double crosses	40.7	0.79	474.6	3.39	867.9	18.19	159.6	0.70	242.2	4.40
General mean	51.3	1.00	318.9	2.09	672.8	12.72	170.6	0.73	197.9	3.75
Sz 28										
Inbred lines	68.0	—	60.3	0.42	379.9	7.49	60.7	0.39	121.2	2.31
Single crosses	72.5	—	72.5	0.55	407.7	8.17	286.7	1.90	266.5	5.01
Double crosses	59.7	—	78.1	0.58	401.0	8.40	367.9	2.23	255.5	5.05
General mean	66.7	—	70.3	0.52	396.2	8.02	238.4	1.51	214.4	4.12

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Table 7

Correlation coefficients between some characters at different periods

Periods and treatments	Character	Character: total chlorophyll	nucleic acid	$^{14}CO_2$
Control chamber plants	fresh weight	−0.31	−0.23	−0.14
Three weeks old	total chlorophyll	—	−0.90	−0.60
	nucleic acid	—	—	0.10
	fresh weight	−0.29	0.30	0.93
Four weeks old	total chlorophyll	—	−0.99	−0.10
	nucleic acid	—	—	0.32
	fresh weight	−0.30	0.99	0.40
Five weeks old	total chlorophyll	—	—	−0.80
	nucleic acid	—	—	0.30
Low temperature treatment	fresh weight	−0.30	0.90	0.10
Three weeks warm +	total chlorophyll	—	−0.30	−0.31
one week cold	nucleic acid	—	—	0.10
Three weeks warm	fresh weight	−0.10	0.99	0.99
+ one week cold	total chlorophyll	—	−0.80	0.68
+ one week warm	nucleic acid	—	—	0.32

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SPACE DOMAIN OF PIXELS IN MONOLAYER TISSUE CULTURES MORPHOMETRIC ANALYSIS I.

1.0 Introduction. At present tissue cultures can be regarded as one of the most sensitive biological titrating systems (APARICIO *et al.* 1968, BOZSIK—SCHMIDT 1980, BROOKS 1976, EAGLE—FOLEY 1958, ÓVÁRY—BENCZE 1965, ÓVÁRY 1969, PAPP 1980, RUTTER—MANNWEILER 1977, STUPFEL 1975). In the instrumental evaluation of monolayer tissue cultures great progress was made with the introduction of computer-aided TV-image analysis systems. This has made it possible to detect very small quantities of toxic materials by light microscopy. This is important in biotoxicity and environmental protection studies, as well as in diagnostic teratology (BOZSIK—SCHMIDT 1980). Morphometry is also useful in the examination of cell movement, transport, cytoskeleton and intercellular communication in tissue cultures (BÁN 1977, 1979, HEJNOWICZ 1970, JANKA *et al.* 1980, JUHÁSZ-NAGY—VIDA 1978, KOCH 1979, LATZKOVITS *et al.* 1980, LAZARIDES—REVEL 1979, MOONEN—FRANCK 1977, OTHMER—ALDRIDGE 1978, ÓVÁRY *et al.* 1980, ROISEN *et al.* 1978).

1.1 Material. BHK 21 fibroblast cultures grown in Dulbecco's synthetic medium with 20% foetal calf serum were used.

The culture were randomly divided into five equal groups:

Group 1 served as control.

Group 2 received $CuCl_2$ with a final concentration of 5×10^{-7}.

Group 3 received $CuCl_2$ with a final concentration of 10^{-9}.

Group 4 was infected with 0.1 PFU (plaque forming unit) per cell Morbilli-virus.

Group 5 was infected with 0.01 PFU per cell Morbilli-virus.

After 3, 4, . . . 11 days of reincubation the samples of cultures were fixed with 5% buffered neutral formol. The cytoskeleton was visualized using the method described by Gallyas and modified by the authors. With light microscopy no difference was detectabe between the variously treated cultures (Figs 1a, **1b**).

1.2 Data processing by computer-aided TV-image analyser. An OPTON Mikrovideomat I computer-aided TV-image analyser was used combined with a scanning stage. It was interfaced to an IBM typewriter, with a Wang 720 C software programmed computer. The examinations were performed with a $25 \times$planachromatic objective to provide an adequate range of focusing. This set-up produced an image with a 350 μm X axis and a 240 μm Y axis on the TV-screen. The total image area was 84.000 μm^2 per scanned pixel. The average cell number per pixel was 500 fibroblasts (minimum 50, maximum 5000) From the uniform monolayer cultures the scanned area was selected so as not to avoid any "empty" pixels. To obtain the specific grey level range of the cytoskeletons, an appropriate standard reference filtering was provided (i.e. the discrimination selected the darker and brighter areas simultaneously). The correctness of filtration was also checked by negative discrimination too (Figs 2*a*, 2*b*, 2*c*).

By moving the stage along the X and Y axes, it was possible to scan a minimum of 100 and a maximum of 800 pixels.

During the examination the adequate focusing was controlled visually.

Data Pre-processing. The individual pixel density values printed by the computer were threshold-functioned later manually. For this purpose the "absolute" numbers are given in square micrometres to allow for adequate mapping of the data. For the mappings the whole unit surface of 84,000 μm^2 was divided into 17 density categories. The theoretical reasons for this division will be given in the next paper.

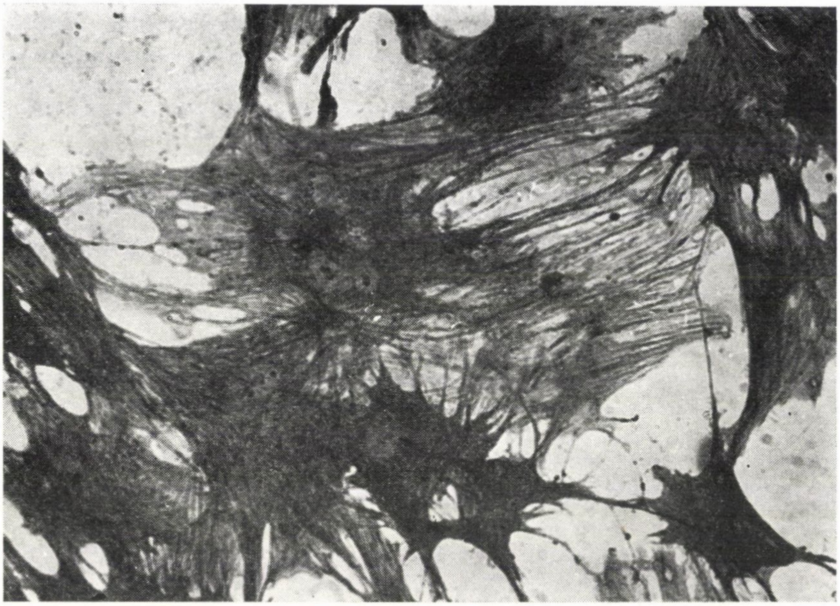


Fig. 1a. 10-day-old fibroblast culture, control. In the cytoplasm the fascicular arrangement of the cytoskeleton is distinctly visible. The more compact perinuclear cytoskeleton covers the nucleus with a network. Gallyas' modified fibre impregnation. Zeiss 25 × obj., 10 × oc

Fig. 1b. 10-day-old fibroblast culture. $CuCl_2$ 5×10^{-7} M cc. The cytoskeleton is distinctly visible. Gallyas' modified fibre impregnation. Zeiss 25 × obj., 6.3 × oc

Fig. 2a. TV-screen photo. BHK 21 fibroblast, 3-day-old control culture. The bundle-like arrangement of fibroblasts is clearly visible. Gallyas' modified fibre impregnation. X = 350 μm, Y = 240 μm

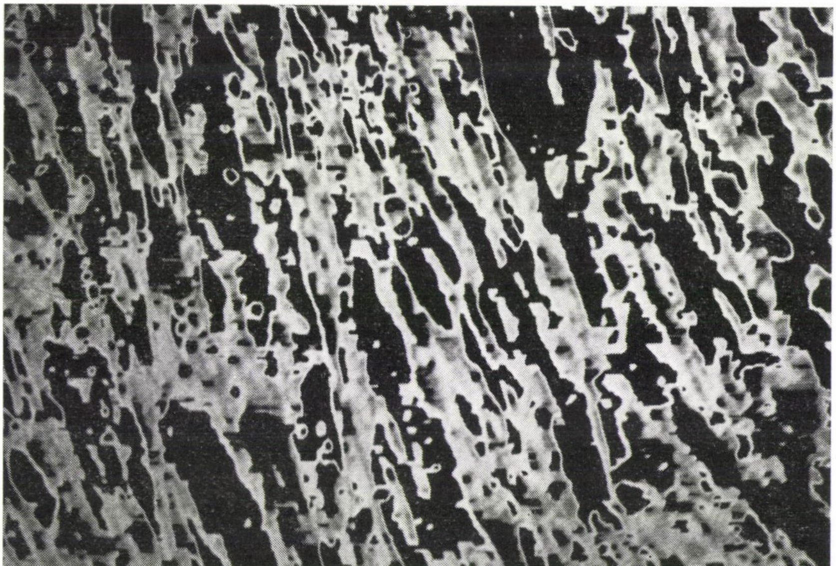


Fig. 2b. The 2/a TV-screen photo discriminated to the cytoskeleton; magnification unchanged

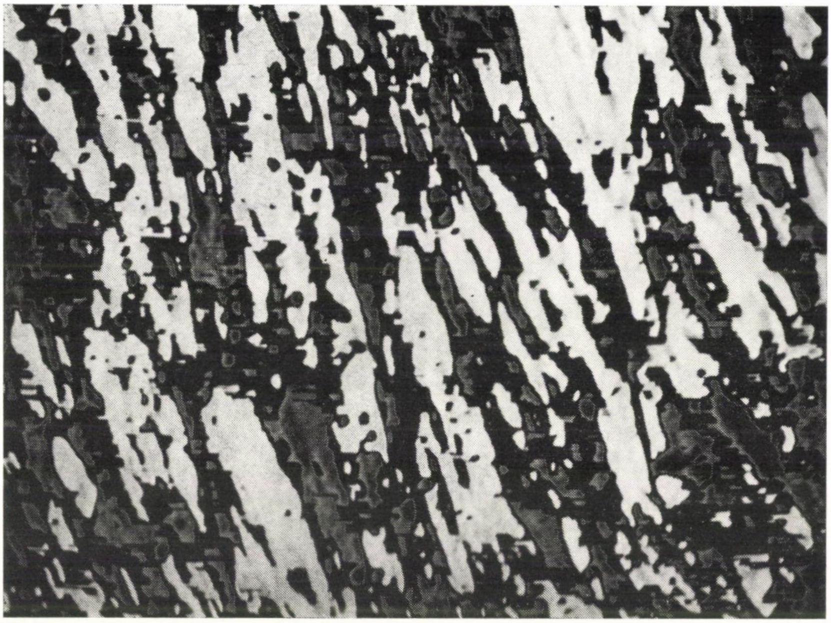


Fig. 2c. Fig. 2a in negative discrimination

The 17 density categories used were as follows:

Density (in square micrometric intervals)	Density category code (threshold function)
0 — 6,000.0	1
6,000—10,000.0	2
10,000—15,000.0	3
15,000—20,000.0	4
20,000—25,000.0	5
25,000—30,000.0	6
30,000—35,000.0	7
35,000—40,000.0	8
40,000—45,000.0	9
45,000—50,000.0	10
50,000—55,000.0	11
55,000—60,000.0	12
60,000—65,000.0	13
65,000—70,000.0	14
70,000—75,000.0	15
75,000—80,000.0	16
80,000—84,000.0	17

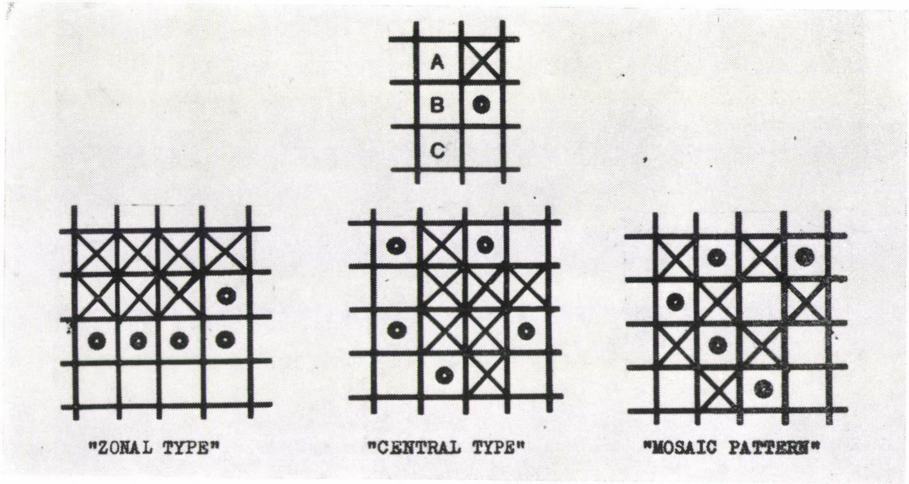


Fig. 3. Zonal, central or mosaic-like topology can be produced from the same number of elements

After the scanning and printing out of the data for each individual pixel the following final data were printed: mean density with standard deviation and percentage density taking the density of 84,000 μm^2 as 100%. The individual absolute density data were each categorized into one of the 17 density categories.

2.0 Data mapping (revisualisation). The data were mapped by putting the adequate code figures for each pixel, corresponding to their real topological positions, into a pre-printed quadratic lattice. The final map was redrawn in colour, representing the density scales with 17 different colours and shades.

2.1 Processing of maps. The conventional statistical analysis of the maps does not supply explicit information on the mean, median and standard deviation of the measured density values within the space domain structure of the scanned culture.

Two cultures with completely identical mean density and standard deviation may exhibit fundamentally different patterns due to the topology of the individual pixels, since even at a constant mean relative frequency of individual density values a broad variety of patterns can be constructed (KOCH 1979).

Let us consider three simple examples in a 4×4 quadratic lattice using the code numbers: 7, 5, 4, each at a constant mean relative frequency (Figs 3*a*, 3*b*, 3*c*).

The three main types of patterns shown are called "zonal", "central", and random "mosaic-like".

2.2 The mathematical methods used to characterize the spatial structure yields two new types of information. First, it is possible to characterize the position of the individual pixels relative to their surroundings. Secondly, it is possible digitalize the structure of the whole culture.

2.3 The mathematical methods used. The basic density map served as the point of departure. The different densities were considered to represent different levels of biological activity.

1. Analysis of surroundings

Let us call the medial pixel D_i and its 8 nearest neighbours D_{ij} (Fig. 4).
Index j is the number of joint pixels ($1 \ldots n$) with a quadrangular lattice $n = 8$.
The sophisticated surroundings

$$S_i = \frac{D_i}{\frac{\sum_{j=1}^{8} D_{ij}}{8}} = \frac{8\,D_i}{\sum_{j=1}^{8} D_{ij}}$$

where

D_i = the "individual" medial pixel density code number,

$\sum_{j=1}^{8} D_{ij}$ = the sum of the density code number values of the joint pixels,

$\frac{\sum_{j=1}^{8} D_{ij}}{8}$ = the mean of the density of the joint pixels.

When calculating the sophisticated surroundings the first top left pixel with a complete set of 8 nearest neighbours is taken first. (The authors are aware of the possible error caused by arbitrarily disregarding the marginal pixels.)

S_i indicates the activity (density) of the central pixel relative to its 8 nearest neighbours. Thus, by mapping the Si values we derive an "activity map".

If $S_i > 1$, the surroundings are said to be "more developed",
if $S_i < 1$, the surroundings are said to be "underdeveloped",
if $S_i = 1$ the situation is ambivalent.

Ambivalent situations may be produced by different sets of pixels with different density levels. Since the mean of the densities of the surroundings is taken when calculating S_i, the topological features of the "density patterns" are concealed.

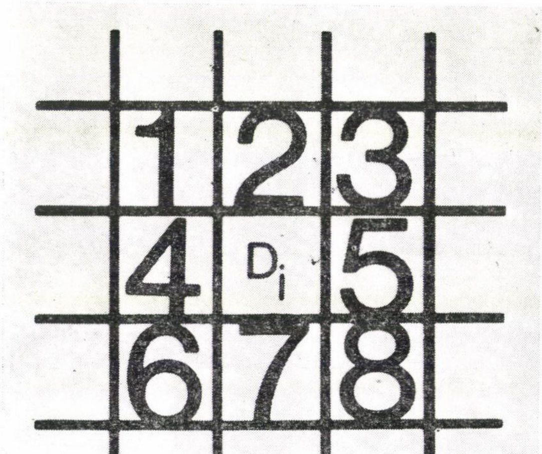


Fig. 4. Pixel *D*i and its surroundings

Flow analysis. Part of the information lost by using means in calculating S_i can be recovered by calculating a set of 2×4 axial gradients for each set of pixels. Using a clockwise rotating triangular sector for dissecting the 8 D_{ij} pixel frame around D_i, four subfragments are obtained. The subfragments obtained by sequential quadrant rotations are symbolized by $\varnothing$s: ($k = 1,2 \ldots 8$).

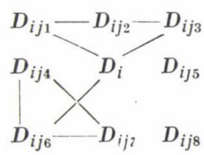
$$\varnothing_1 = \frac{3\,D_i}{D_{ij1} + D_{ij2} + D_{ij3}} \qquad \varnothing_6 = \frac{3\,D_i}{D_{ij2} + D_{ij3} + D_{ij5}}$$

$$\varnothing_2 = \frac{3\,D_i}{D_{ij3} + D_{ij5} + D_{i,8}} \qquad \varnothing_6 = \frac{3\,D_i}{D_{ij5} + D_{ij8} + D_{ij7}}$$

$$\varnothing_3 = \frac{3\,D_i}{D_{ij6} + D_{ij7} + D_{ij8}} \qquad \varnothing_7 = \frac{3\,D_i}{D_{ij7} + D_{ij6} + D_{ij4}}$$

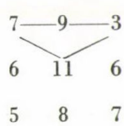
$$\varnothing_4 = \frac{3\,D_i}{D_{ij1} + D_{ij4} + D_{ij6}} \qquad \varnothing_8 = \frac{3\,D_i}{D_{ij4} + D_{ij1} + D_{ij2}}$$

Subfragments 1 . . . 4 are called orthogonal and 5 . . . 8 diagonal for the reasons shown below:

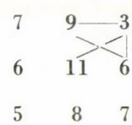


The "triangle" is in the $\varnothing_1$ and the "arrow is in the $\varnothing_7$ position.

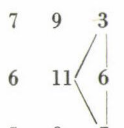
Let us consider these possibilities using some realistic density code number in a 3×3 lattice.



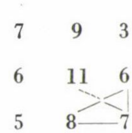
$\varnothing_1 = \frac{33}{19} = 1.74$



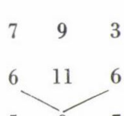
$\varnothing_5 = \frac{33}{18} = 1.83$



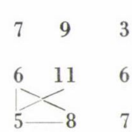
$\varnothing_2 = \frac{33}{16} = 2.06$



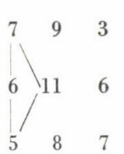
$\varnothing_6 = \frac{33}{21} = 1.57$



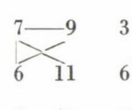
$\varnothing_3 = \frac{33}{20} = 1.65$



$\varnothing_6 = \frac{33}{19} = 1.74$



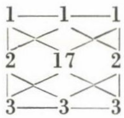
$\varnothing_4 = \frac{33}{18} = 1.83$



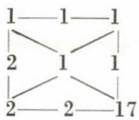
$\varnothing_8 = \frac{33}{22} = 1.50$

Let us further consider an example where the 3×3 lattice is shifted sequentially from right to left over a row of the density map.

a)



b)



$\varnothing_1 = \frac{51}{3} = 17.0$ $\quad \varnothing_5 = \frac{51}{4} = 12.75$ $\quad \varnothing_1 = \frac{3}{3} = 1.0 =$ no flow !

$\varnothing_2 = \frac{51}{6} = 8.5$ $\quad \varnothing_6 = \frac{51}{8} = 6.37$ $\quad \varnothing_2 = \frac{3}{19} = 0.16$ countertype flow

$\varnothing_3 = \frac{51}{9} = 5.66$ $\quad \varnothing_7 = \frac{51}{8} = 6.37$ $\quad \varnothing_3 = \frac{3}{21} = 0.14$ countertype flow

$\varnothing_4 = \frac{51}{6} = 8.5$ $\quad \varnothing_8 = \frac{51}{4} = 12.75$ $\quad \varnothing_4 = \frac{3}{5} = 0.60$ countertype flow

If $\varnothing_k > 1$ (max: 17.0) transport from the centre to the periphery is possible.
If $\varnothing_k = 1.0$ no transport is possible.
If $\varnothing_k < 1.0$ transport from the periphery to the centre is possible.

Pixel sets with $\varnothing_k > 1$ are called donors and those with $\varnothing_k < 1$ acceptors. Fig. 5 shows a "flow map" constructed according to the above principles.

Fig. 5. Diagonal flow analysis map of a 6-day-old control culture (quadratic lattice)

2. The concept "potential"

The orthogonal and diagonal flows of activity in a set of one medial pixel and its 8 nearest neighbours were determined in the previous section. The results suggested that the dynamics of a culture may be characterized more realistically by considering such sets than just a map of individual densities per pixel. The flow activities actually represent interactions between individual pixels. Mapping the flow activities resulted in a graph showing the main directions of activity flows within a cultured cell monolayer.

The flow of activity from one set of pixels to the other suggests a difference in some sort of "activity potential" between them. This expression is borrowed from physics to define the potential of a set of one medial pixel and its 8 nearest neighbours as

$$P_i = D_i \cdot \sum_{j=1}^{8} D_{ij}$$

where D_i and D_{ij} are the same terms as those defined above. The P_i values obtained were referred either to the maximum P_i value found in the given culture (P_i max. rel.) or to be "absolute" maximum ($17 \cdot 136 = 2312$) of P_i/P_i max. abs.) as 100%. The relative values thus obtained were mapped in a quadratic lattice in adequate topological relation to the original pixel map. The potential maps revealed the topology and size of relative or "absolute" potential peaks or pits depending on the reference P_i.

3. Further possibilities of applying surroundings and potential analyses

It is assumed that in interpreting short-term actions the relations to the surroundings (∅) are of importance, while for "long-term" processes potential analysis is required. It is this dialected duality that creates a deep relation of principle in the interpretation of the two simple approaches.

None of the methods suggested is in itself suitable for the full characterisation of the cultures. This needs an integration of all of them, together with adequate mathematical-statistical evaluation, verbal-visual analysis and an interpretation of the differents maps.

*

Prepared at Eötvös Loránd University, Department of Regional Geography, Budapest,* Semmelweis Medical University, Psychiatric Clinic, Budapest;** Semmelweis Medical University, 2nd Institute of Pathological Anatomy-*** Eötvös Loránd University, Department of Petrography and Geochemistry;**** Semmelweis Medical University, Institute of Biochemistry.*****

J. Nemes Nagy,* I. Óváry,** E. Csonka,***
I. Kubovics,**** S. Fazekas,*****, I. Németh*

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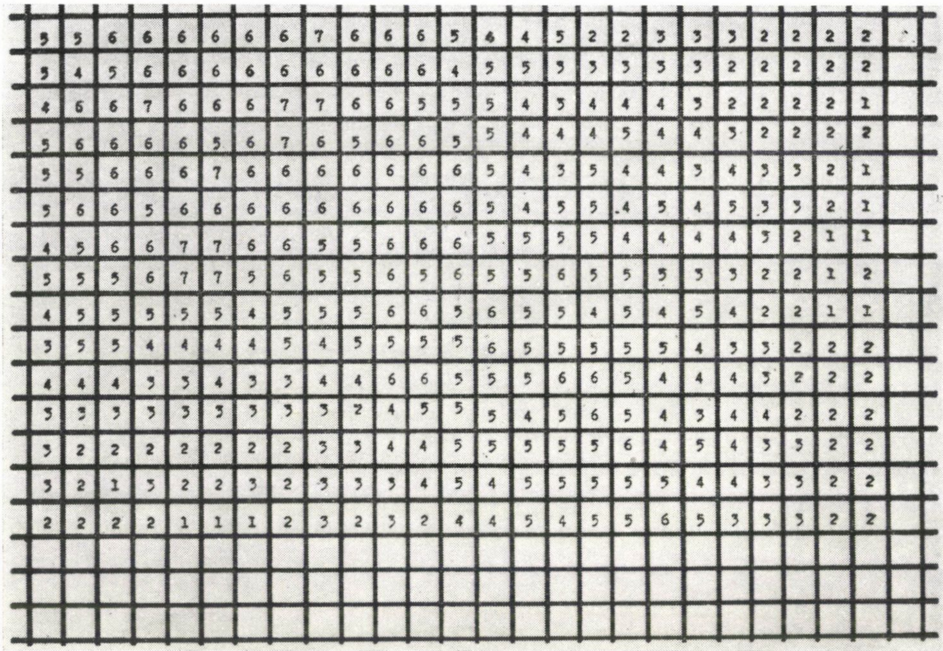


Fig. 6a. 6-day-old control culture. Density code map

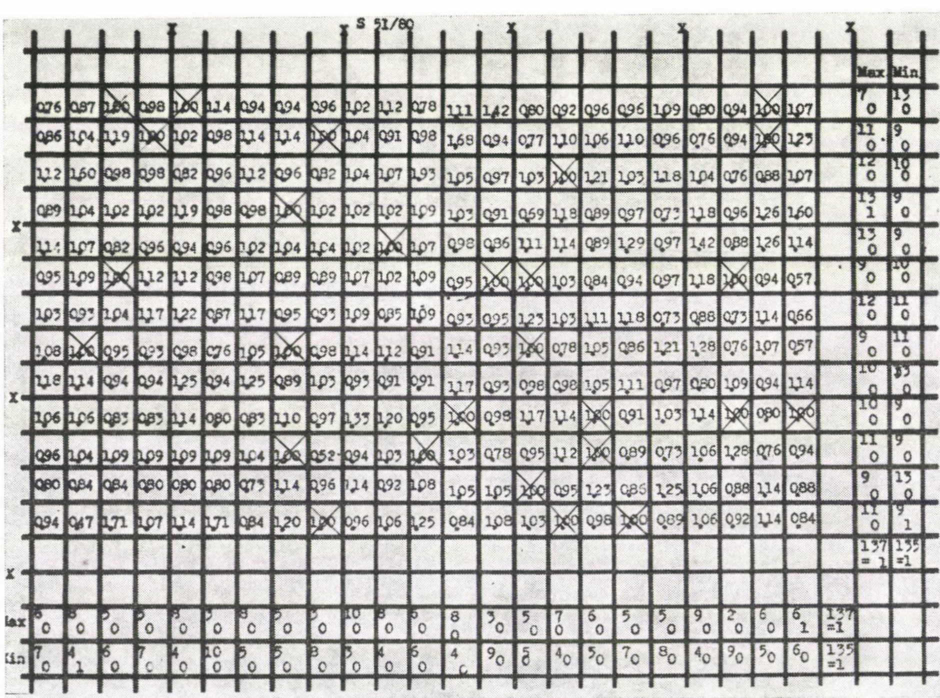
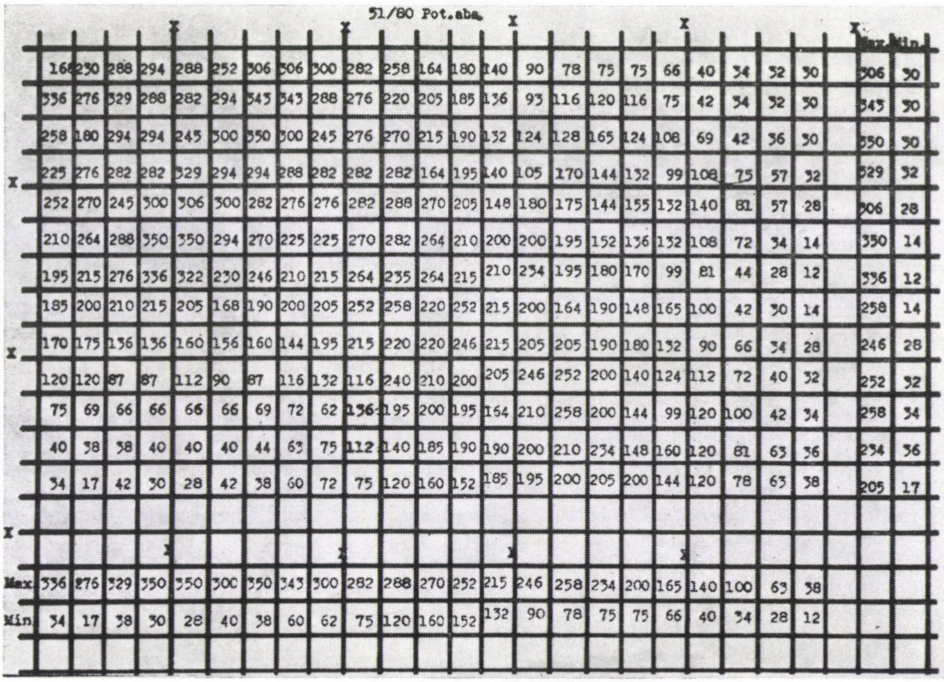


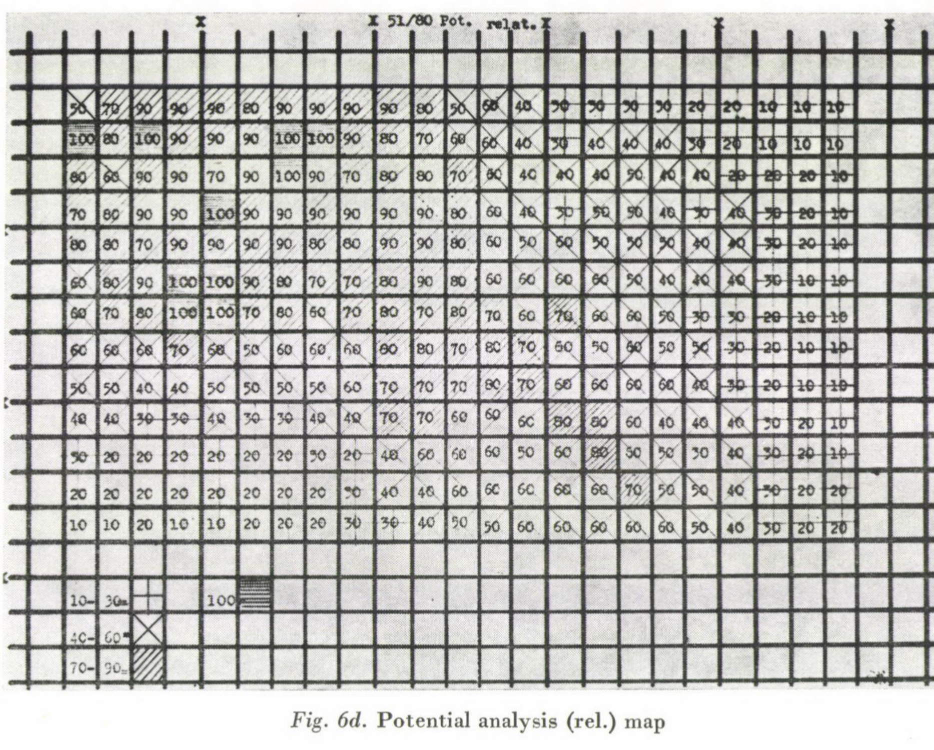
Fig. 6b. S_i map. The ambivalent pixels are marked X. At the margine of the map a minimum-maximum evaluation zone is given (on the X and Y-axis, respectively)



51/80 Pot.abs.

																							Max.	Min.
	168	230	288	294	288	252	306	306	300	282	258	164	180	140	90	78	75	75	66	40	34	32	30	306	30
	336	276	329	288	282	294	343	343	288	276	220	205	185	136	93	116	120	116	75	42	34	32	30	343	30
	258	180	294	294	245	300	350	300	245	276	270	215	190	132	124	128	165	124	108	69	42	36	30	350	30
X	225	276	282	282	329	294	294	288	282	282	282	164	195	140	105	170	144	132	99	108	75	57	32	329	32
	252	270	245	300	306	300	282	276	276	282	288	270	205	148	180	175	144	155	132	140	81	57	28	306	28
	210	264	288	350	350	294	270	225	225	270	282	264	210	200	200	195	152	136	132	108	72	34	14	350	14
	195	215	276	336	322	230	246	210	215	264	235	264	215	210	234	195	180	170	99	81	44	28	12	336	12
	185	200	210	215	205	168	190	200	205	252	258	220	252	215	200	164	190	148	165	100	42	30	14	258	14
X	170	175	136	136	160	156	160	144	195	215	220	220	246	215	205	205	190	180	132	90	66	34	28	246	28
	120	120	87	87	112	90	87	116	132	116	240	210	200	205	246	252	200	140	124	112	72	40	32	252	32
	75	69	66	66	66	66	69	72	62	136	195	200	195	164	210	258	200	144	99	120	100	42	34	258	34
	40	38	38	40	40	40	44	63	75	112	140	185	190	190	200	210	234	148	160	120	81	63	36	234	36
	34	17	42	30	28	42	38	60	72	75	120	160	152	185	195	200	205	200	144	120	78	63	38	205	17
Max.	336	276	329	350	350	300	350	343	300	282	288	270	252	215	246	258	234	200	165	140	100	63	38		
Min.	34	17	38	30	28	40	38	60	62	75	120	160	152	132	90	78	75	75	66	40	34	28	12		

Fig. 6c. Potential analysis (abs.) map



51/80 Pot. relat.

50	70	90	90	90	80	90	90	90	90	80	50	60	40	30	30	30	30	20	20	10	10	10
100	80	100	90	90	90	100	100	90	80	70	60	60	40	30	40	40	40	30	20	10	10	10
80	60	90	90	70	90	100	90	70	80	80	70	60	40	40	40	50	40	40	20	20	20	10
70	80	90	90	100	90	90	90	90	90	90	80	60	40	30	50	50	40	30	40	30	20	10
80	80	70	90	90	90	90	80	80	90	90	80	60	50	60	50	50	50	40	40	30	20	10
60	80	90	100	100	90	80	70	70	80	90	80	60	60	60	60	50	40	40	40	30	10	10
60	70	80	100	100	70	80	60	70	80	70	80	70	60	70	60	60	50	30	30	20	10	10
60	60	60	70	60	50	60	60	60	60	80	70	80	70	60	50	60	50	50	30	20	10	10
50	50	40	40	50	50	50	50	60	70	70	70	80	70	60	60	60	60	40	30	20	10	10
40	40	30	30	40	30	30	40	40	70	70	60	60	60	80	80	60	40	40	40	30	20	10
30	20	20	20	20	20	20	30	20	40	60	60	60	50	60	80	50	50	30	40	30	20	10
20	20	20	20	20	20	20	20	30	40	40	60	60	60	60	60	70	50	50	40	30	20	20
10	10	20	10	10	20	20	20	30	30	40	50	50	60	60	60	60	60	50	40	30	20	20

10–30 =
40–60 =
70–90 =
100 =

Fig. 6d. Potential analysis (rel.) map

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EFFECT OF NITROGEN FERTILIZATION RATES AND TIME OF HARVESTING ON YIELD AND YIELD COMPONENTS OF THE MEXIPACK WHEAT CULTIVAR (T. AESTIVUM L.)

Wheat is the most important food for man on a worldwide basis. To increase the yield of wheat, good agricultural practices must be used. Among these practices is the application of an optimum rate of nitrogen fertilization and the selection of the most suitable stage of maturity at which the grain should be harvested. The annual recommendation of the Wheat Department of the Agricultural Research Center at Giza indicates that delaying harvesting until the moisture content of the grain is sufficiently low for it to be safely stored results in some loss due to head breakage, shattering and weathering. HEMISSA *et al.* (1971) and REHMAN *et al.* (1971) reported that the yield increased gradually as the rate of nitrogen fertilizer increased up to 132 kg N/ha. KHALIL—ABOU EL FITTOUH (1972) also showed that the Egyptian wheats Giza 144, Giza 155 and Baladi 116 responded to nitrogen fertilization up to 96 kg N/ha.

The aim of this investigation was to study the effect of nitrogen fertilization rates and time of harvesting on the yield and yield components of Mexipack wheat cultivar under Egyptian conditions.

This investigation was conducted at the farm of the Faculty of Agricultural Science at Moshtohor, Kaliobia, Egypt during the 1974/75 and 1975/76 seasons.

The soil type was clay loam. The wheat variety Mexipack 69 *(T. aestivum)* was sown in a clay loam soil after maize in both seasons. The available nitrogen was 0.068% for the depth of soil equal to 0—40 cm depth. A split-plot design with 5 replications was used. The main plots were the nitrogen rates which were zero, 48, 96, 144 and 192 kg N/ha. The sub-plots were 10.5 m^2 in size and were occupied by times of harvesting which were B_1 = at the beginning of fully ripe stage when the kernels cannot be dented if pressed with the thumb nail (180 days from sowing time) and B_1 = 10 days after the beginning of fully ripe stage (190 days from sowing time). At sowing time all treatments received the same quantity of phosphorus which was 38.4 kg P_2O_5/ha in the form of superphosphate (16% P_2O_5). The nitrogen fertilizer was applied before the first irrigation (one month after sowing) in the form of ammonium nitrate (33.5% N). Four irrigations were applied during the growing season. At the maturity stage ten plants were collected at random from each sub-plot to calculate all data except the grain yield, which was determined on a sub-plot basis. The data were statistically analysed for the following characters: grain yield (kg/ha), number of kernels per spike, weight of kernels per spike (g), weight of spike (g), 1000-kernel weight (g), plant height (cm), number of tillers per plant and number of spikes per plant.

Combined analysis for the two years was carried out for all characteristics except the number of tillers and spikes per plant. The results presented in the tables indicate that any two values within the same treatment not followed by the same letter are significantly different at the 5% level according to Duncan's Multiple Range Test.

Grain yield. The results in Table 1 show that the rates of nitrogen significantly increased the grain yield. The economic rate was obtained when 144 kg N/ha was added, whereas the heavier application was unprofitable. The highest increase in grain yield was obtained when the rate of nitrogen was increased from 96 to 144 kg N/ha. It was observed that the increase in grain yield resulted from an increase in the 1000-kernel weight, weight of kernels per spike and number of tillers and spikes per plant. On the other hand, the grain yield was significantly decreased (795.6 kg/ha) by delaying the time of harvesting by about 10 days after the beginning of the fully ripe stage (B_2) compared to the first harvesting (B_1). It was evident that the decrease in grain yield as affected by harvesting time, resulted from a decrease in the number of kernels per spike, kernel weight per spike, 1000-kernel weight and spike number per plant. The decrease in the number of spikes per plant and the number of kernels per spike at the second harvesting might be due to head breakage and shattering. It was also observed that the interaction between the rates of nitrogen fertilizer and the time of harvesting was significant (Table 3). The highest grain yield was obtained from the treatment that received 192 kg N/ha at the first harvesting (B_1), while the lowest one was obtained with zero fertilizer at the second harvesting (B_2). However, the interaction year × rates of nitrogen fertilizer as well as year × rates of N fertilizer × time of harvesting had insignificant effects on the grain yield. The above results emphasized that nitrogen fertilizer encouraged the metabolic processes in the wheat plant and this in turn stimulated the growth, which might account for the superiority of yield and yield components. These results agree with those obtained by EL-RAYES (1971), HEFNI (1973) and WAHAB *et al.* (1976) who found that wheat responds well to nitrogen fertilization. The results were also in agreement with those obtained by KOLTAY (1965) who reported that the addition of nitrogen increased the yield of wheat.

Yield components. The combined analysis (Tables 1 and 2) for the number of kernels per spike, spike weight and plant height showed that these characters were not significantly

Table 1

Mean values of yield and yield components of wheat as affected by rates of nitrogen and time of harvesting Mexipack wheat cultivar

Rate of nitrogen, kg/ha	Grain yield, kg/ha			Kernel number/spike			Kernel weight/spike			Number of spikes per plant
	1975	1976	Comb.	1975	1976	Comb.	1975	1976	Comb.	
0	3024.00a	2750.40a	2887.200a	38.51a	39.80	39.15	1.56a	1.52	1.54a	5.27a
48	3898.80b	3963.60b	3931.20b	42.10b	38.88	40.49	1.75b	1.65	1.70b	5.75b
96	4611.60c	4791.60c	4701.60c	42.92c	39.46	41.19	1.61a	1.60	1.60a	5.43a
144	5947.20d	5922.00d	5032.80d	42.57b	39.36	40.96	1.64ab	1.58	1.61a	5.23a
192	6220.50d	6282.60d	6253.20e	42.40b	39.95	41.17	1.64ab	1.60	1.62ab	5.80b
F. test	++	++	++	++	NS	NS	+	NS	+	++
Time of harvesting:										
B_1	5180.40	5097.60	5137.20	48,93	47.20	48,05	1.95	1.85	1.90	5.73
B_2	4298.40	4384.80	4341.60	34.46	31.77	33.12	1.32	1.32	1.32	5.26
F. test	++	++	++	++	++	++	++	++	++	++

B_1 = Harvesting at the beginning of fully ripe stage.
B_2 = Harvesting 10 days after the beginning of fully ripe stage.
+, ++ and SN = Significant at 5% and 1% level and not significant, respectively.

Table 2

Mean values for some yield components as affected by rates of nitrogen and time of harvesting of Mexipack wheat cultivar

Rate of nitrogen, kg/ha	Spike weight (g)			1000-kernel weight (g)			Plant height (cm)			Number of tillers per plant
	1975	1976	Comb.	1975	1976	Comb.	1975	1976	Comb.	
0	2.27	2.42b	2.34	33.58a	33.74a	33.66a	112.40	107.28	109.84	6.78a
48	2.38	2.15a	2.26	42.77d	44.27c	43.52d	116.00	107.54	112.27	7.34b
96	2.31	2.50b	2.40	40.05c	42.19c	41.12c	115.90	114.38	115.14	6.61a
144	2.48	2.39b	2.43	38.96c	37.44b	38.20b	115.30	108.12	111.71	6.76a
192	2.34	2.50b	2.42	36.80b	36.68b	36.74b	114.40	111.70	113.05	8.38c
F-test	NS	+	NS	++	++	++	NS	NS	NS	++
Time of harvesting:										
B_1	2.72	2.66	2.69	39.54	40.36	39.95	114.68	110.02	112.35	7.32
B_2	1.98	2.11	2.05	37.31	37.36	37.34	114.92	109.98	112.45	7.02
F-test	++	++	++	++	++	++	NS	NS	NS	NS

B_1 = Harvesting at the beginning of fully ripe stage.
B_2 = Harvesting 10 days after the beginning of fully ripe stage.
+, ++ and NS = Significant at 5% and 1% level and not significant, respectively.

affected by the rate of nitrogen. These results agree with those obtained by WOODWARD (1966) and BLACK (1970) who mentioned that nitrogen did not increase the number of kernels per spike or the weight of kernels.

KHATTAB (1958) reported that the plant height of Egyptian wheat was not significantly affected by nitrogen rate. However, the mean kernel weight per spike, 1000-kernel weight and number of tillers and spikes per plant were significantly increased due to the nitrogen rates. These results agree with those obtained by WAHAB *et al.* (1976) who found that nitrogen increased the number of heads and tillers per plant and the 1000-kernel weight of wheat. Highly significant decreases in the number of kernels per spike, kernel weight per spike, 1000-kernel weight, spike weight and spikes per plant were observed at the second harvesting (B_1) as compared with the first harvesting (B_2).

Number of kernels per spike. The results recorded in Table 1 show that the number of kernels per spike was not affected by the application of nitrogen. The number of kernels per spike decreased approximately 31.1% at the second harvesting (B_2) relative to the first (B_1). Analysis of variance indicated a significant interaction between the rates of nitrogen fertilizer and the time of harvesting. The highest number of kernels per spike (50.64) was obtained from the treatment which received 192 kg N/ha at the first harvesting (B_1), while the lowest

Table 3

Mean values of combined analysis for grain yield and yield components as affected by the interaction between rates of nitrogen and time of harvesting of Mexipack wheat cultivar

Characteristic		Rate of Nitrogen kg N/ha					
		0	48	96	144	192	F
Grain yield (kg/ha)	B_1	3074.4 a	4302.0 b	5155.2 c	6447.6 d	6715.6 c	
	B_2	2700.0 a	2840.4 b	4248.0 c	5421.6 d	6508.8 c	++
Spike weight	B_1	2.50a	2.64a	2.88c	2.72ab	2.78bc	
	B_2	2.19b	1.89a	1.96a	2.15ab	2.06a	++
Kernel number per spike	B_1	43.50a	47.04b	49.20bc	49.96c	50.64c	
	B_2	31.81b	33.94ab	33.18a	31.97a	71.71a	++
Kernel weight/ spike (g)	B_1	1.75a	1.90bc	1.85ab	1.95ed	2.07d	
	B_2	1.33b	1.50c	1.35bc	1.27ab	1.17a	++
No. os spikes per plant	B_1	5.38a	5.90b	5.84b	5.68b	5.88b	
	B_2	5.16b	5.66c	5.02ab	4.78a	5.72d	++
No. of tillers per plant	B_1	6.76a	7.26b	7.04ab	6.92a	8.62c	
	B_2	6.80b	7.42c	6.18a	6.60b	8.14d	++
Plant height (cm)	B_1	110.84a	114.02b	113.50b	112.52ab	110.88a	
	B_2	108.84a	110.52a	116.78c	110.90a	115.22bc	++

B_1 = Harvesting time at the beginning of fully ripe stage.
B_2 = Harvesting time 10 days after the beginning of fully ripe stage.
++ = Significant at 1% level of probability.

one (31.71) was obtained from the treatment that received 192 kg N/ha at the second harvesting (B_2) (Table 3). The combined analysis showed a significant difference due to years $\times$ rates of nitrogen. It was observed that the number of kernels per spike decreased gradually as the rate of nitrogen increased at the second harvesting (B_2).

Kernel weight per spike. The kernel weight per spike increased slightly when 48 kg N/ha were added, while the heavier application was unprofitable. The second time of harvesting decreased the kernel weight per spike as compared with the first. This decrease resulted from the decrease in the number of kernels per spike. The mean weight of kernels/spike was significantly affected by the interaction between the rates of N fertilizer and the time of harvesting (Table 3). The highest mean kernel weight per spike (2.07 g) resulted from the addition of 192 kg N/ha at the first harvesting (B_1), while the lowest one (1.17 g) was obtained from the application of 192 kg N/ha at the second harvesting.

Spike weight. The combined analysis (Table 2) indicated insignificant differences among the means of spike weight for different rates of nitrogen. However, the second harvesting significantly decreased the mean spike weight relative to the first harvesting (B_1). The decrease in the number of kernels per spike was due to the time of harvesting. The highest spike weight (2.88 g) was obtained with 96 kg N/ha at the first harvesting while the lowest one was obtained from the application of 48 kg N/ha at the second harvesting (Table 3). The interactions between years $\times$ rates of nitrogen and between years $\times$ harvesting time were significant.

1000-kernel weight. The combined means for 1000-kernel weight (Table 2) show that there was a significant increase due to the rates of nitrogen relative to the control. It was observed that the 1000-kernel weight reached its maximum as a result of the application of 48 kg N/ha. The difference between the treatments 144 kg N/ha and 192 kg N/ha was not significant. The 1000-kernel weight significantly decreased at the second harvesting relative to the first harvesting. The decrease in 1000-kernel weight probably resulted from the decrease in grain moisture content at the second harvesting.

Plant height. Plant height was not affected either by the application of nitrogen or the time of harvesting, but the interaction between them was significant (Table 3).

Number of tillers per plant. The number of tillers per plant (Table 2) significantly increased due to the application of 48 or 192 kg N/ha compared with the control. The increase in the number of tillers per plant probably resulted from the activity of the buds, which was affected by the application of nitrogen. The highest number of tillers per plant (8.62) was obtained from the addition of 192 kg N/ha at the first harvesting. The lowest number of tillers per plant (6.18) was obtained with 96 kg N/ha at the second harvesting.

Number of spikes per plant. The number of spikes per plant (Table 1) significantly increased due to the application of 48 or 192 kg N/ha. This increase resulted from an increase in the number of tillers per plant. The number of spikes per plant was significantly decreased at the second harvesting as compared with the first one. The decrease in the number of spikes per plant at the second harvesting (B_2) might be due to head breakage, shattering and weathering (Delorit—Ahlgren 1959). The effect of the interaction between rates of nitrogen fertilizer and time of harvesting on the number of spikes per plant was significant.

Table 3 indicates that the interaction between nitrogen fertilizer rates and harvesting time gave the highest grain yield, spike weight, kernel number, kernel weight, number of spikes per plant and number of tillers per plant due to the addition of 192 kg N/ha at the first harvesting (B_1), whereas the highest plant height was obtained at the second harvesting due to the addition of 96 kg N/ha.

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Prepared at the Agronomy Department, Faculty of Agricultural Science, Moshtohor

E. H. M. Hefni

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PERFORMANCE OF MIXTURES OF UPRIGHT BUNCH AND SPREADING BUNCH VARIETIES OF GROUNDNUT UNDER TWO PLANT SPACINGS

Pure varieties are usually the objective of most of the crop improvement programmes. Research in some crops such as oats have shown a yield advantage when using variety mixtures as reported by BROWNING (1957). KLAGES (1936) reported the yields for three stem rust susceptible wheat varieties grown in individual mixtures of different percentage composition with the stem rust resistant variety Mindum in a season when stem rust was severe. The yields of Mindum in the various mixtures were in direct relationship to the stem rust damage to the susceptible varieties. Barley variety mixtures were tested extensively by HARLAN—MARTINI (1938). In experiments with a mixture of 11 varieties of barley grown for four to twelve years at ten stations, they found evidence of early aggressiveness and increasing dominance of the local commercial type at certain stations.

SUNESON—WIEBE (1942) concluded that the high yielding and widely adapted varieties of Vaughn barley and Ramona wheat were poor competitors in mixtures with other varieties having slightly lower individual yields. STRINGFIELD (1959) tested 42 pairs of corn hybrids separately and as two-hybrid mixtures in three tests. He failed to show any significant yield advantage in planting the mixtures. PENDLETON—SEIF (1962) observed a yield reduction in mixing normal and dwarf corn.

The groundnut varieties M.H.383, a spreading bunch type, and Barberton, an upright bunch, were chosen for this study. These were planted alone and in varying mixtures. Ashford, a spreading bunch type which has been substituted by M.H.383, was used as a check. The variety mixtures were planted at a spacing of 60 cm between ridges, 15 and 30 cm between holes and two kernels per hole. The treatments were:

M.H.383 alone
Barberton alone
80% M.H.383 : 20% Barberton
60% M.H.383 : 40% Barberton

40% M.H.383 : 60% Barberton

20% M.H.383 : 80% Barberton

Ashford alone

The data reported here were obtained from an experiment conducted at G.R.S.* in three seasons 1970/71 to 1972/73. The type of soil was heavy, dark, cracking clay with a pH of about 8.5 and a low nitrogen status. The average rainfall for the three seasons was about 300 mm.

The experimental design consisted of a split-plot design with the variety mixtures as main-plots and the between-hole spacings as sub-plots. The sub-plot size was 9.9 m×4.2 m, replicated six times. All the operations were done manually except for the land preparation. The variety mixtures were planted every year on 1st July after cotton. On the day of planting the kernels were treated with Aldrex T at 2.2 g per kg of kernels. The variety mixtures were irrigated at two-week intervals; about 400 m^3 per hectare were applied in each watering. The plots were reridged after 45 days (at flowering) and weeded three times at monthly intervals, starting a month after planting.

For ascertaining groundnut harvesting losses, the plants of one ridge per each sub-plot were used at the time of harvesting for the following determinations:

a) percentage pods harvested (on plant)

b) percentage gleanings

c) percentage remaining in soil and thereby lost

(it was necessary to dig the soil to ascertain this part).

The oil content of the shelled nuts was determined by the laboratory press method (Nur 1976). The amount of pods used for the shelling percentage determinations was 300 g Nur—Gasim 1976). Samples for the determination of oil and shelling percentages were obtained from the bulked seed of each sub-plot, with five determinations per sub-plot.

A seed germination test for the three varieties was conducted every season prior to conducting the experiment; it was found that the seed germination was 100%.

Ashford was introduced in 1930 and was previously the only groundnut variety grown under irrigation in Sudan. Recently it was found by Nur (1977) that M.H.383 (an Indian variety introduced from Nigeria) is superior to Ashford in pod yield, oil and shelling percentages. Barberton is a lower yielder than Ashford and M.H.383, but it has a greater oil and shelling percentage than either of them.

Total pod yield. Significant differences were noted in total pod yield among the varieties and between hole spacings, but no significant interaction was observed between variety and spacing treatments. Mixtures having the highest proportion of M.H.383 yielded significantly more than the one having the lower proportion of M.H.383, as expected; Barberton alone resulted in the lowest yield (Table 1). 15 cm spacing gave higher yields than 30 cm spacing for each of the variety mixtures tested.

Oil content, shelling percentage and losses at harvest. The effect of variety mixtures and spacing on the oil content of the shelled nuts, shelling percentage and losses at harvest is summarized in Table 1. In the three attributes tested Barberton was superior and mixtures having the highest proportion of Barberton resulted in more favourable values than the one having the lower proportion of Barberton.

Ashford was next to M.H.383 in all the attributes tested; each of the variety mixtures and Barberton in pure stand were better than Ashford in oil and shelling percentages and resulted in lower harvest losses than Ashford.

The effect of treatments was consistent from season to season; there was no treatment×season interaction.

* G.R.S. = Gezira Research Station, Wad Medani, Sudan.

Table 1

Effect of spacing and variety mixtures on yield and other attributes of groundnut
Variety Mixtures

Between-holes spacing (cm)	M.H. 383 alone	Barberton alone	80% M.H. 383, 20% Barberton	60% M.H. 383, 40% Barberton	40% M.H. 383, 60% Barberton	20% M.H. 383, 80% Barberton	Ashford alone
Total pod yield (kg/ha)							
15	5398	3501	4671	4370	4086	3790	5003
30	5032	3204	4350	4100	3785	3500	4740
	Spacing S.E. ± 86.6			Variety mixtures S.E. ± 94.9			
Oil percentage							
15	49.18	52.19	49.63	50.10	50.60	50.99	48.75
30	49.21	52.08	49.64	50.00	50.50	50.87	48.70
			Variety mixtures S.E. ± 0.13				
Shelling percentage							
15	73.47	78.14	74.22	75.17	76.16	77.01	72.60
30	73.50	78.09	74.18	75.25	76.00	76.94	72.44
			Variety mixtures S.E. ± 0.25				
Losses at harvest (percentage remaining in the soil)							
15	14.8	1.5	12.4	10.0	7.6	5.1	17.7
30	15.3	1.7	12.4	10.3	7.5	5.2	18.0
			Variety mixtures S.E. ± 0.75				

Although groundnut is an extremely important crop and offers many advantages as an experimental material, no work has been reported on the performance of mixtures, especially when varying the percentage of two different branching types in the mixture and varying the hole spacing to determine an optimum for highest yield.

The value of the mixtures obtained in this study, for the different attributes tested, was within the ceiling value of the pure line. There is little evidence obtained in this experiment to suggest increased yield from competition between plants of M.H.383 and Barberton. This does not prove that such phenomena do not exist in other genotypes or under other conditions.

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Prepared at the Gezira Research Station, Wad Medani

I. M. Nur

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INHERITANCE AND INSERTION OF MALE STERILITY IN WATERMELON CULTIVARS, CITRULLUS LANATUS, THUNBERG

For the production of F_1 watermelon, different cultivars must be crossed by hand-pollination and emasculation should be carried out for andromonoecious plants. These practical processes multiply the costs for obtaining commercial F_1. Thus, male sterility is the best way of minimizing these processes and hence the expense. Therefore, research was carried out to try to obtain male steriles of widely extended cultivars in Egypt for use essentially in practice as a maternal parent in hybrid seed production fields and as a genetic marker in the detection of outcrosses.

Plant breeders have been stimulated to discover male sterility in several vegetable crops, such as onion, tomato, squash, watermelon, pumpkin, pepper, eggplant, carrot and other plants. Recently WATTS (1962) found a mutant in an X_2 population derived from irradiated Sugar Baby watermelon where it produced glabrous plants.

Three cultivars, Congo, Giza 1 and Male-Sterile, were used in this investigation at the Vegetable Crop Research Station at Giza, Faculty of Agriculture, Cairo University, from 1971 to 1976. The Congo and Male-Sterile cultivars were introduced from U.S.A. but Giza 1 was a local cultivar in Egypt with andromonoecious flowers. The crosses were made after selfing Congo and Giza 1 for several generations. Also, the Male-Sterile cultivar, which carries male sterile character, was selfed to produce male sterile and male fertile plants. The male sterile plants were used in the crosses as the female parent with the other two cultivars to produce F_1, F_2, first backcross and second backcross to study the inheritance of this character and obtain a strain of Male-Sterile Congo.

x^2 analysis was used for this study.

Two crosses were used to study the mode of inheritance of this character. These were:

1. Male-Sterile × Congo
2. Male-Sterile × Giza 1

Data of the first cross shown in Table 1 indicate that all the F_1 plants produced male fertile flowers, indicating that male sterility is recessive.

The plants of seven F_2 populations segregated according to the ratio 3 male fertile: 1 male sterile with x_2 values ranging from 0.0055 to 2.7778 and P values ranging from 0.10 to 0.95. All these populations were homozygous since there was a heterogeneity x^2 value of 4.0898 and a P value of 0.50—0.75 on the basis of 3 : 1.

Ten F_2 families were obtained by selfing 10 F_2 male fertile plants selected at random. Six of the F_2s gave only male fertile progenies. This would indicate the homozygosity of the selfed F_2 plants (MsMs). The remaining four F_2 families gave segregating F_3 progenies with a good fit to the 3 male fertile: 1 male sterile ratio. This would indicate that the selfed F_2 plants were heterozygous (Msms) for one pair of genes.

In the first backcross of the Male-Sterile cultivar to F_1 plants, the resultant progeny segregated according to the ratio 1 male fertile : 1 male sterile. On the other hand, F_1 plants backcrossed to the dominant parent, i.e. Congo, produced male fertile plants (MsMs and Msms). On selfing these plants for two generations, some of them produced only male fertile

Table 1

Expression of Male sterility in Parents, F_1, F_2, F_3 and First and Second Backcross Populations in the cross: Male-Sterile 100 × Congo 101

Pedigree	Generation	No. of plants observed: fertile	No. of plants observed: sterile	Ratio	x^2	P
100-8	P_1		8			
101-5	P_2	10				
100-8 × 101-5	F_1	6				
100-10 × 101-7	F_1	5				
102-1 F_1 Selfed	F_2	40	11	3 : 1	0.3203	0.50—0.75
102-2 F_1 Selfed	F_2	78	23	3 : 1	0.2673	0.50—0.75
102-3 F_1 Selfed	F_2	45	17	3 : 1	0.1935	0.50—0.75
104-4 F_1 Selfed	F_2	31	17	3 : 1	2.7778	0.05—0.10
103-1 F_1 Selfed	F_2	46	19	3 : 1	0.6205	0.25—0.50
103-2 F_1 Selfed	F_2	46	15	3 : 1	0.0055	0.90—0.95
103-3 F_1 Selfed	F_2	28	13	3 : 1	0.9837	0.25—0.50
Total x^2					5.1686	0.50 к0.75
Pooled x^2		308	115	3 : 1	*1.0788*	0.25—0.50
Heterogeneity x^2					4.0898	0.50—0.75
126-2 F_2 Selfed	F_3	18	8	3 : 1	0.4615	0.25—0.50
126-4-1 F_2 Selfed	F_3	20	15	3 : 1	5.9524	0.01—0.025
127-1 F_2 Selfed	F_3	40	0			
128-2 F Selfed	F_3	41	0			
128-4-1 F_2 Selfed	F_3	44	0			
129-1 F_2 Selfed	F_3	35	0			
129-3-1 F_2 Selfed	F_3	23	4	3 : 1	1.4938	0.10—0.25
130-1-2 F_2 Selfed	F_3	24	0			
131-3 F_2 Selfed	F_3	32	9	3 : 1	0.2033	0.50—0.75
131-4 F_2 Selfed	F_3	32	0			
100-8 × F_1	BC_1P_1	9	11	1 : 1	0.2000	0.50—0.75
F_1 × 101-5	BC_1P_2	20				
132-3 BC_1P_2 Selfed		15				
132-5 BC_1P_2 Selfed		20				
132-6 BC_1P_2 Selfed		18	5	3 : 1	0.1304	0.50—0.75
132-7 BC_1P_2 Selfed		11	3	3 : 1	0.0952	0.75—0.90
132-9 BC_1P_2 Selfed		22				
132-11 BC_1P_2 Selfed		20	6	3.::1	0.0513	0.75—0.90
132-12 BC_1P_2 Selfed		24	9	3 : 1	0.0909	0.75—0.90
132-15 BC_1P_2 Selfed		17				
133 (Selected msms × 101) BC_2P_2		18	0			
133-3 BC_2P_2 Selfed		81	20	3 : 1	1.4554	0.10—0.25
133-4 BC_2P_2 Selfed		66	30	3 : 1	2.0000	0.10—0.25
133-6 BC_2P_2 Selfed		45	12	3 : 1	0.4737	0.25—0.50
133-7 BC_2P_2 Selfed		58	15	3 : 1	0.7717	0.25—0.50
133-9 BC_2P_2 Selfed		22	11	3 : 1	1.2222	0.25—0.50
133-11 BC_2P_2 Selfed		34	19	3 : 1	3.3270	0.05—0.10
Total x^2					9.2500	0.10—0.25
Pooled x^2		306	107	3 : 1	*0.1816*	0.50—0.70
Heterogeneity x^2					9.0684	0.10—0.25

Table 2

Expression of Male Sterility in Parents, F_1 and F_2 Populations in the Cross: Male-Sterile 100-3 × Giza 1 134-6

Pedigree	Generation	No. of plants observed		Ratio	x^2	P
		fertile	sterile			
100-3	P_1		5			
134-6	P_2	10				
100-3 × 134-6	F_1	13				
100-7 F_1 Selfed	F_2	69	28	3 : 1	0.7732	0.25—0.50

(MsMs) and the others produced male fertile and male sterile in a 3 : 1 ratio. Some of these male sterile plants, which were similar to Congo in shape and colour, were crossed to Congo again in a second backcross. All the plants of the resultant second backcross were male fertile (Msms). The selfing of these plants produced progenies segregating according to the ratio 3 : 1. Thus, by means of this second backcrossing, the selected male sterile strain resembled Congo in most characters.

It is concluded from the data on F_1, F_2, F_3, and first and second backcross populations that this character is monogenically inherited and that male sterility is recessive. The same results were found in F_1 and F_2 in the cross between Male-Sterile and Giza 1 (Table 2).

All the male sterile flowers were distinguished by glabrous plants in all generations. These data substantiate those reported by WATTS (1962).

The factorial analysis for obtaining strains of Male-Sterile Congo is as follows:

P_1	msms			Male sterile
P_2	MsMs			Male fertile
F_1	Msms			Male fertile
F_2	MsMs 1 } Msms 2 } 3 (3×)			Male fertile
	msms		1	Male sterile
BC_1 to Ms cv.		Msms	1	Male fertile
		msms	1	Male sterile
BC_1 to Congo		MsMs, Msms		Male fertile
BC_1 to Congo		Selfing for MsMs gave: MsMs		Male fertile
BC_1 to Congo		Selfing for Msms gave:		
	MsMs 1 } Msms 2 } 3 (3×)			Male fertile
	msms 1			Male sterile
BC_2 (Selected msms from segregating BC_1 to Congo) x Congo gave:				
	Msms 1			Male fertile
BC_2 Selfing	MsMs 1 } Msms 2 } 3 (3×)			Male fertile
	msms 1			Male sterile

From the segregation of the selfed second backcross, msms strains similar to Congo were selected and named Male-Sterile Congo.

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Prepared at the Department of Horticulture, Faculty of Agriculture, Cairo University, Cairo

A. A. A. EL-HAFEZ

A NEW IGR COMPOUND AS SOIL PESTICIDE AGAINST LARVAE AND PUPAE OF SPODOPTERA LITTORALIS (BOISD.)

A major objective in recent efforts to improve the quality of our environment has been the development of methods for insect pest control, more selective in action than the broad-spectrum insecticides. Among the approaches being explored is the possibility of controlling insect pests by causing derangement of their growth processes with their own hormones (JH) or related compounds acting as insect growth regulators (IGRs). The effects of insect growth regulators (IGRs) on lepidopterous larvae have received relatively little attention compared to the importance of the majority of them as destructive pests on several crops.

Recently, however, due to the availability of IGR compounds, these have been used with some success on certain lepidopterous larvae, such as *Pieris brassicae* and *Barratra brassicae* (Mulder—Swennen 1973), *Pectinophora gossypiella* (Agripino *et al.* 1974), *Spodoptera littoralis* (Rizk—Shoukry 1974) and *S. littoralis* and *Pectinophora gossypiella* (Rizk—Radwan 1974). In most of these studies, the IGR compounds were tested either as a food additive or as foliage application.

Little information has been reported on the response of lepidopterous larvae to IGRs applied as soil treatment (Rizk—Radwan 1975). Therefore the present study deals with the effects of an IGR compound, known to interfere with chitin biosynthesis (Post—Vincent 1973), when applied as soil treatment against both larvae and pupae of the cotton leafworm *Spodoptera littoralis* (Boisd.) which is presently the most expensive cotton pest to control in Egypt.

Two separate tests were conducted to emphasize the biological activity of an IGR compound (PH 6040) as soil surface treatment against the cotton leafworm. One test was carried out against the larval stage while the other was undertaken against the pupal stage. Both were obtained from a laboratory-reared colony. The insect rearing colony was maintained for 4 years without intentional exposure to insecticides under laboratory conditions at 25 ± 2 °C and $65 \pm 5\%$ R.H.

An aqueous solution of the tested IGR compound, PH 6040 (1-(4-chlorophenyl)-3-(2,6-difluorobenzoyl)urea) W.P. 25%, was prepared to provide concentrations of 1, 10, 100 and 1000 ppm. Pots 15 cm in diameter each containing loamy clay soil, were irrigated to nearly the field capacity prior to adding the tested concentration. A volume of 75 ml of the tested concentration was applied to the soil surface of each pot (Harris 1966, 1967). Four replicates were used for each treatment. Dursban W.P 25% and Gardona W.P 50% were used in the same way in a pupal test for comparison. Pots treated with equivalent amounts of tap water were run in a similar manner as a check.

For larval tests, the 4th, 5th and 6th instar larvae were chosen for testing according to their behaviour as partially soil-insects. Ten larvae were introduced into each pot subsequent to the soil treatment (40 larvae/treatment). The larvae were provided with castor-bean leaves as food till pupation.

For pupal tests, ten 6th instar larvae of the same age were introduced into each pot prior to the soil treatment and were left to pupate naturally in the soil. These pots were checked daily and the 24—36 hr old pupae in the soil were treated, adopting the same technique as in the larval tests within 24 hr of pupation. In both tests pupal mortality and adult eclosion were recorded, while larval and prepupal mortality were recorded in larval tests only.

Table 1 presents the relative susceptibility of different larval instars of the cotton leaf-worm exposed to IGR-treated soil. The larval mortality data revealed that the 4th instar larvae were more sensitive than the 5th, while the latter were more susceptible than the 6th instar larvae. This correlation between larval development and sensitivity may be attributed mainly to the period elapsing between the larval exposure period in contact with the treated

Table 1

Larval and pupal mortality of S. littoralis following exposure of different larval instars to soil treated with PH 6040 (IGR)

Larval instar	Concentration of IGR in ppm				
	0	1	10	100	1000
	% larval mortality				
4th	0	7.5	12.5	32.5	90
5th	0	5	7.5	17.5	65
6th	0	0	0	2.5	2.5
	% pupal mortality				
4th	2.5	15	32.5	67.5	10
5th	5	30	45	82.5	35
6th	0	50	90	97.5	97.5
	% accumulated mortality				
4th	2.5	22.5	45	100	100
5th	5	35	52.5	100	100
6th	0	50	90	100	100

soil and their ecdysis to the sixth instar, which took place 7 and 10 days later for the 5th and 4th instar larvae respectively. During this period 2 moulting processes occurred for the 4th and 1 for the 5th instar. However, WELLINGA *et al.* (1973a, b) stated that death in insects treated with PH 6040 was invariably connected with moulting, where the compound mostly interfered with integument formation. Also POST—VINCENT (1973) reported that the larvicidal properties of PH 6040 compound is most probably based on the inhibition of chitin biosynthesis.

Regarding the latent biological activity of the compound consequent to exposing different larval instars to PH 6040 treated soil, it is clearly obvious that the pupal stage was highly affected (expressed as an increase in the pupal mortality percentage). Also, it could be observed that this indirect effect on the pupal stage was more highly pronounced than the direct effect on the larvae exposed directly to the treated soil. While the mortality percentages at a concentration of 10 ppm reached 12.5, 7.5 and 0% for the 4th, 5th and 6th instar larvae respectively, it reached 32.5, 45.0 and 90% for pupae formed with the same treatment.

Regarding the delayed effect, expressed as accumulated mortality, it is quite obvious that the accumulated mortality for the 4th instar larvae was the least. By contrast, there was a higher accumulated mortality percentage for the 6th instar larvae. This performance of the IGR compound revealed the importance of considering the percentage of adult emergence as a final and more reliable criterion in this respect.

Complete inhibition (100%) of adult emergence was found at concentrations of 100 and 1000 ppm for all instars tested (Table 2). Meanwhile the same concentrations induced, for example, 32 and 90% larval mortality in the most susceptible instar (4th). SHAEFER *et al.* (1974) indicated that TH 6040 causes mortality in the pupal stages and interferes with adult emergence in addition to inhibiting moulting in mosquito larvae.

The direct pupicidal effect of the IGR (PH 6040) compound with Dursban and Gardona was studied against naturally pupated cotton leafworm in the soil. The results obtained (Table 3) revealed that as low as 10% pupal mortality was achieved for all concentrations of the IGR compound tested. On the other hand, both Dursban and Gardona induced highly pronounced pupal mortality, which increased positively with the increase in the concentration tested. However, WRIGHT (1970) reported that the JH analogues (IGRs) should penetrate the breeding material to the sites where the larvae are pupating, so that the maximum amount of the compound is present when the insect reaches its most susceptible life stage, the 0-hr-old pupa. This may explain the poor performance of PH 6040, since it was tested on 24—36 hr-old pupae.

Tracing the latent effects of either the IGR compound (PH 6040) or the standard insecticides on the basis of adult emergence percentage, the results in Table 4 indicate that the highest percentage adult emergence was recorded with PH 6040 treatments. In contrast, Dursban produced the lowest adult emergence for all concentrations tested. Gardona gave inferior results, but still gave higher adult eclosion than PH 6040. The most distinct effect of the IGR compound on pupae was to induce deformities in the resulting moths. The malformation percentage and the degree of deformity increased with the increase in the con-

Table 2

Adult eclosion percentages following exposure of different larval instars of S. littoralis to soil treated with PH 6040 (IGR)

Larval instar	% Adult eclosion at conc. (ppm)				
	0	1	10	100	1000
4th	97.5	77.5	55	0	0
5th	95	65.0	47.5	0	0
6th	100	50.0	10	0	0

Table 3

Pupal mortality percentages of S. littoralis naturally pupated following soil surface application of the IGR compound (PH 6040), compared with certain soil pesticides

Treatments	% Pupae Mortality at indicated concentration (ppm)				
	1	10	100	1000	Average
PH 6040 (Dimilin)	10	10.0	10.0	10.0	10.0
Dursban	15	22.5	17.5	82.5	41.9
Gardona	10	12.5	20.0	30.0	18.1
Check	—	—	—	—	7.5

Table 4

Adult emergence and malformation of S. littoralis following soil surface application of IGR (PH 6040) compared with certain soil pesticides

Treatment	Conc. ppm.	% Adult emergence		
		healthy	malformed	total
PH 6040 (Dimilin)	1	90	0	90.0
	10	87.5	2.5	90.0
	100	67.5	22.5	90.0
	1000	55.0	35.0	90.0
Dursban	1	85.0	0	85.0
	10	77.5	0	77.5
	100	40.0	12.5	52.5
	1000	15.0	2.5	17.5
Gardona	1	90.0	0	90.0
	10	87.0	0	87.5
	100	80.0	0	80.0
	1000	65.0	5.0	70.0
Check	0	92.5	0	92.5

centration tested. The percentage of adult malformation reached 0, 2.5, 22.5 and 35% for concentrations of 1, 10, 100 and 1000 ppm of PH 6040 respectively.

El-Tantawi (1973), in a similar experiment for detecting the effect of JH on pupae in the soil, reported that the adults emerging from treated pupae were malformed. Also, it was found that the activity increased with increasing doses of JH. Furthermore, he reported that the numbers of eggs laid by the adults emerging from treated pupae, as well as the percentage hatchability, decreased with increasing doses of JH.

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Prepared at the Plant Protection Department, Faculty of Agriculture, Shebin El-Kom

M. R. Abo-Elghar, H. S. A. Radwan, I. M. A. Ammar

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SEED GERMINATION IN CASSIA SOPHERA L.

Cassia sophera L., a member of the *Leguminosae*, is an undershrub with yellow flowers (GAMBLE 1957). A native of South America, it extends from the Himalayas to Ceylon and Penang and is cosmopolitan in the tropics (HOOKER 1879). The species is a common weed in uncultivated lands (COOKE 1958), growing by road-sides and on waste places. Its seeds start sprouting in and around Calcutta after receiving the pre-monsoon showers in April. Flowers are produced throughout the rainy season and massive fruiting occurs from the beginning of winter. Enormous amounts of seeds fall to the ground due to the dehiscence of the mature pods in the month of February.

C. sophera is endowed with medicinal properties (KIRTIKAR—BASU 1918, ANONYMOUS 1948, CHOPRA *et al.* 1956). A decoction of the entire plant is considered to be a cure for acute bronchitis. The leaves are used externally for skin diseases. The seeds and leaves are antiperiodic; these, along with roots, are regarded as a purgative.

Since the plant reproduces solely by seeds, it is worthwhile to study its germination responses. Preliminary experiments revealed that freshly harvested seeds are completely dormant and there is an appreciable loss of dormancy as the seed becomes old. This investigation deals with the regulation of germination in seeds of *C. sophera*, which has not been studied in detail before.

Matura pods of *C. sophera* were collected locally and stored in brown paper containers in the laboratory for one year. Healthy seeds were selected and scattered on a single disk of filter paper (Whatman No. 1) in 7-cm sterile glass Petri-dishes to which 2 ml distilled water was added. Unless otherwise mentioned, all tests were performed in a germinator set at 25 ± 1 °C. Each dish was inspected daily for a period of 3 days, after which the experiments were discontinued. The protrusion of the radicle through the testa was employed as a criterion for germination. The results are expressed as a percentage of imbibition and germination as well as root growth (cm).

a) *Effect of wetting agent under varying temperature and light conditions:* At first, the seeds were sown on filter paper moistened with 0.5—2.0 ml water. The dishes containing the seeds were placed in the light and dark chambers of the germinator at constant temperatures of 20, 25, 30 and 35 °C.

The most effective amount of wetting agent for good germination was 2 ml (Table 1). Though this value was noted at 25 and 35 °C (dark only), the lower temperature tends to keep

Table 1

Cassia seed germination under variable moisture, temperature, etc. conditions

Amount of wetting agent (ml)	Temperature (°C)	Percentage germination	
		Light	Dark
0.5	20	0	0
	25	12.5 ± 3.3	42.5 ± 0.4
	30	40.0 ± 0.7	77.5 ± 1.4
	35	0	52.5 ± 1.5
1.0	20	0	50.0 ± 0.6
	25	67.5 ± 0.5	77.5 ± 0.5
	30	60.0 ± 1.3	77.5 ± 0.3
	35	7.5 ± 0.4	70.0 ± 1.1
2.0	20	50.0 ± 0.7	60.0 ± 0.7
	25	77.5 ± 0.6	80.0 ± 0.9
	30	70.0 ± 0.8	77.5 ± 0.3
	35	30.0 ± 0.6	80.0 ± 1.1

the seeds more moist and the higher more dry. In both light and dark, the seeds failed to germinate at 20 °C with 0.5 ml water. This was also the case at 20 °C with 1.0 ml and at 35 °C with 0.5 ml, when germination took place in the light. There was very poor response at 25 °C with 0.5 ml and at 35 °C with 1.0 ml; these responses were obtained when the seeds were exposed to light. With illumination, less than 50% of the seeds germinated at 35 °C with 0.5 ml and also at the same temperature with 2 ml. In the rest of the treatments, the germination percentages were above 50%. Striking differences between the light and dark conditions were registered at 35 °C for all three amounts of wetting agent. Such differences were also noticed at 25 and 30 °C with 0.5 ml and at 20 °C with 1.0 ml.

b) *Effect of high temperature stimulus:* Seeds were dry-heated in a ventilated oven at 60—100 °C for 24—72 hr, then set out in dishes with 2 ml water and placed in the light and dark chambers of the germinator.

When the dry seeds were subjected to pre-treatments at constant temperatures of 90 and 100 °C, they imbibed considerably but failed to germinate. If the seeds were pre-treated at 60 °C, the desired responses were still poor. However, both imbibition and germination improved against the longer duration of dry-heating at 70 °C. The same cannot be said about 80 °C, where there was high imbibition in the light with 48-hr pre-treatment and high germination in the dark with 72-hr pre-treatment.

c) *Effect of salinity:* The influence of salinity was studied by germinating seeds in solutions of NaCl of various concentrations (0.025 – 0.2 *M*), using the same amount (2 ml) of solution in all the dishes. This experiment was conducted in the dark chamber of the germinator.

In all cases of salinity, the percentage of imbibition remained the same (Table 2). Germination was progressively reduced with higher concentrations of NaCl, the most remarkable being a sharp decline in the value from 0.1 to 0.2 *M*. The results on root growth indicated the same trend as with germination, for relatively few seeds germinated and even produced poor roots at the maximum level of salinity.

Table 2

Imbibition, germination and root growth of Cassia under salinity

Salinity by NaCl (M)	Percentage of imbibed seeds	Percentage of germinated seeds	Root length of germinating seedlgins (cm)
0.025	97.5 ± 2.5	85.0 ± 9.8	1.50 ± 0.02
0.05	95.0 ± 2.9	70.0 ± 14.3	1.02 ± 0.2
0.1	95.0 ± 2.9	60.0 ± 14.3	0.78 ± 0.2
0.2	97.5 ± 2.5	10.0 ± 3.3	0.01 ± 0.1

d) *Effect of water stress:* The water supply of the seeds was varied by keeping them on 1, 2, 3 and 4 disks of filter paper and adding the same quantity of water (2 ml per dish). In this way, the following conditions were created: nil, slight, moderate and extreme water stress. This experiment was also carried out in the dark chamber of the germinator.

There was no effect of water stress on the process of imbibition, as the percentage of imbibed seeds did not differ appreciably under all the conditions of water supply (Table 3). Though germination occurred under all conditions, a very high value was attained with slight water stress and a very low one with extreme water stress. The results on root growth were the same as with the germination percentage, i.e. those germinating well showed maximum root length and those germinating poorly minimum length.

Table 3

Imbibition, germination and root growth of Cassia under varying water stress conditions

Levels of water (with disks of filter paper)	Percentage of imbibed seeds	Percentage of germinated seeds	Root length of germinating seedlings (cm)
1	92.5 ± 2.3	60.0 ± 9.6	0.77 ± 0.2
2	90.0 ± 4.1	75.0 ± 14.3	1.27 ± 0.02
3	97.5 ± 3.8	50.0 ± 9.6	0.59 ± 0.2
4	85.0 ± 6.5	27.5 ± 14.6	0.36 ± 0.2

e) *Effect of water-logging:* Seeds were kept buried in water-logged soil, tied in a piece of nylon cloth, and were removed at intervals for tests.

With water-logging for 3 days, only 20% germination was achieved. Those removed after 7 and 15 days gave still lower levels of germination. When the seeds were treated for 31 days, they did not germinate at all.

f) *Effect of soil moisture:* A weighed quantity of oven-dry soil, contained in Petri-dishes, was moistened with water and allowed to dry so as to maintain moisture levels ranging from 10 to 100% of soil dry weight. Seeds were then sown in each dish.

Table 4

Imbibition, germination and root growth of Cassia at varying soil moisture levels

Percentage of soil moisture	Percentage of imbibed seeds	Percentage of germinated seeds	Root length of germinating seedlings (cm)
10	100.0 ± 0	0	0
20	90.0 ± 4.1	0	0
30	100.0 ± 0	10.0 ± 4.8	0.11 ± 0.2
40	95.0 ± 2.9	25.0 ± 0.9	0.29 ± 0.2
50	95.0 ± 2.9	5.0 ± 6.2	0.06 ± 0.1
60	100.0 ± 0	20.0 ± 12.1	0.25 ± 0.2
70	95.0 ± 2.9	35.0 ± 14.1	0.34 ± 0.3
80	100.0 ± 0	5.0 ± 4.9	0.04 ± 0.01
90	100.0 ± 0	5.0 ± 6.2	0.06 ± 0.3
100	100.0 ± 0	15.0 ± 8.4	0.09 ± 0.8

The seeds imbibed water at all moisture levels (Table 4). With 10 and 20% soil-moisture the seeds failed to germinate. In the rest, the responses were poor and low germination was recorded even with 70% soil-moisture. In the latter, however, root growth was maximum.

g) *Effect of dry storage:* Seeds were collected during the second week of November from six different localities in and around Calcutta. They were stored dry for 1—4 months in the laboratory. Then they were dipped in conc. H_2SO_4 for 20 min and the acid was decanted off. After washing several times in water, they were set to germinate in both light and dark conditions.

The stored seeds germinated poorly before scarification and well after scarification (Table 5). In general, dry storage did not improve subsequent germination either in the light or the dark. There was no correlation between dry storage and the germination of unscarified seeds from any collection site except in locality No. III. In the latter, dark-germination seemed to be stimulated with the progress of the storage period. Also, the light-germination of scarified seeds from locality No. I increased slightly upon dry storage.

h) *Effect of seed extract:* A preliminary study revealed that a pinkish substance diffuses out from the soaked seeds in the course of the germination period. Extracts of old and new seeds were prepared by crushing 50—400 seeds of each kind in 100 ml distilled water. These extracts were tried on both one-year old and freshly collected seeds, the germinating dishes being kept in both light and dark conditions.

The new seed extract failed to break the dormancy of the new seeds (Table 6). On the other hand, the germination of new seeds in the presence of old seed extract was very poor. When the old seed extract was applied to old seeds, the percentage of germination was high.

Table 5

Relation between dry storage and Cassia seed germination

Dry storage (months)	Locality No.	Before scarification		After scarification	
		Light	Dark	Light	Dark
1	I*	0	0	72.5 ± 22.5	100.0 ± 0
	II	0	5.0 ± 4.1	100.0 ± 0	90.0 ± 12.2
	III	0	2.5 ± 3.1	100.0 ± 0	97.5 ± 3.1
	IV	0	5.0 ± 6.2	100.0 ± 0	100.0 ± 0
	V	0	0	80.0 ± 20.3	100.0 ± 0
	VI	0	0	87.5 ± 15.3	100.0 ± 0
2	I	0	0	95.0 ± 6.0	100.0 ± 0
	II	0	0	100.0 ± 0	100.0 ± 0
	III	10.0 ± 4.1	22.5 ± 14.3	72.5 ± 18.5	35.0 ± 16.3
	IV	0	0	77.5 ± 15.3	70.0 ± 28.8
	V	0	0	95.0 ± 6.1	77.5 ± 27.3
	VI	12.5 ± 10.3	12.5 ± 11.0	40.0 ± 24.5	100.0 ± 0
3	I	0	0	100.0 ± 0	97.5 ± 3.1
	II	0	0	100.0 ± 0	100.0 ± 0
	III	15.0 ± 14.3	10.0 ± 8.3	100.0 ± 0	100.0 ± 0
	IV	5.0 ± 6.3	2.5 ± 3.1	97.5 ± 3.1	100.0 ± 0
	V	0	0	100.0 ± 0	100.0 ± 0
	VI	17.5 ± 14.3	0	32.5 ± 13.1	100.0 ± 0
4	I	2.5 ± 3.1	0	100.0 ± 0	100.0 ± 0
	II	0	5.0 ± 6.1	85.0 ± 18.5	100.0 ± 0
	III	5.0 ± 6.1	57.5 ± 30.5	52.5 ± 21.5	25.0 ± 30.7
	IV	5.0 ± 6.1	2.5 ± 3.1	100.0 ± 0	100.0 ± 0
	V	0	0	100.0 ± 0	100.0 ± 0
	VI	15.0 ± 12.5	5.0 ± 6.1	100.0 ± 0	100.0 ± 0

*I — University Campus, Ballygunge, Calcutta.
II — Midnapore, West Bengal.
III — Jangipara, Hooghly, West Bengal.
IV — Subhasgram, 24-Parganas, West Bengal.
V — Kalyani, Nadia, West Bengal.
VI — Santragachi, Howrah, West Bengal.

Upon treating old seeds with the new seed extract, germination decreased appreciably in some of the concentrations. In this case, more seeds germinated in the light than in the dark.

i) *Effect of light intensity:* Imbibed seeds were continuously irradiated by high (1,280 lux), intermediate (389 lux) and low (139 lux) light intensities, by keeping the Petri-dishes at various distances from a cool-white fluorescent lamp.

Table 6

Cassia seed germination with extracts from old and new seeds

Treatment	Light				Dark			
	400*	200	100	50	400	200	100	50
Old seed extract on old seeds	50.0 ±12.0	37.5 ±7.0	35.5 ±8.3	40.0 ±12.0	37.5 ±3.1	47.5 ±10.3	50.0 ±4.1	35.0 ±8.3
Old seed extract on new seeds	0	0	2.5 ±3.1	0	2.5 ±3.1	0	0	0
New seed extract on old seeds	17.5 ±10.3	30.0 ±16.3	50.0 ±4.1	45.0 ±4.1	15.0 ±6.0	15.0 ±8.3	35.0 ±14.3	17.5 ±10.3
New seed extract on new seeds	0	0	0	0	0	0	0	0

* Number of seeds used for the extract.

Table 7

The effect of short light treatment on dark-germination and of short dark treatment on light-germination of Cassia seeds

Treatment	Percentage of imbibed seeds	Percentage of germinated seeds	Root length of germinating seedlings (cm)
Light			
5 min	80.0 ± 0	35.0 ± 12.0	0.77 ± 0.5
10 min	70.0 ± 8.3	40.0 ± 12.0	0.92 ± 0.5
20 min	75.0 ± 4.1	32.0 ± 18.5	0.84 ± 0.4
Dark			
5 min	72.5 ± 6.0	40.0 ± 16.0	0.71 ± 0.3
10 min	70.0 ± 4.1	25.0 ± 10.3	0.36 ± 0.3
20 min	72.5 ± 10.3	32.5 ± 14.3	0.60 ± 0.4

Though the percentage of imbibition (62.5—82.5%) was high under low light intensity, both the germination percentage (32.5—45.0%) and the root growth (0.37—0.43 cm) were slightly affected by a change in the light intensity.

j) *Effect of light/dark and dark/light interaction:* Soaked seeds were exposed to daily periods of illumination (1,280 lux) from a cool-white fluorescent lamp lasting 5, 10 and 20 min and then transferred to a dark chamber for the rest of the cycle. Similarly, the seeds were kept in the dark chamber for 5, 10 and 20 min and shifted to the light chamber for the remaining time. The transfer from light to dark and vice-versa was continued for 3 days (3 cycles).

None of the above treatments improved the imbibition of the seeds (Table 7). With the 10-min treatment, both the germination and the root growth of dark-germinated seedlings were higher than those of the corresponding light-germinated seedlings. With the 20-min treatment, the root growth increased more in the dark-grown seedlings than in the light-grown ones.

k) *Effect of light quantity:* The effectiveness of different spectral regions was examined by wrapping in a double layer of coloured cellophane and exposing the germinating dishes to the same light intensity (1,280 lux) from a cool-white fluorescent lamp. A dark control was maintained throughout the experiment.

Under all colours of light, a high percentage of imbibition (92.5—97.5%) took place. Unlike the dark control (77.5%), the light quality has a depressive action on germination; this action was evident in violet (57.5%), blue (57.5%) and green (55.0%) light. Though the effect of darkness on root length did not differ significantly from that of blue, yellow and orange light, white light exhibited slightly enhanced root growth (1.03 cm) and violet, green and red light reduced the root growth (0.70—0.75 cm).

l) *Effect of chemical substances:* Seeds were soaked in different concentrations (1.0×10^{-2} and 5.0×10^{-2} *M*) of chemical substances such as thiourea, potassium thiocyanate, potassium nitrate and manganese sulphate. A dish without chemical solution and with plain distilled water served as the control. This experiment was performed in the dark chamber of the germinator.

Compared to the water control, the percentage of imbibition did not differ greatly in any of the chemical treatments (Table 8). Only a solution of 5.0×10^{-2} *M* potassium thiocyanate reduced germination far below that of the untreated seeds. The germination values

Table 8

Imbibition, germination and root growth of Cassia with various chemical substances

Chemical substance (M)	Percentage of imbibed seeds	Percentage of germinated seeds	Root length of germinating seedlings (cm)
Thiourea			
1.0×10^{-2}	97.5 ± 3.5	57.5 ± 12.0	0.81 ± 0.02
2.5×10^{-2}	100.0 ± 0	70.0 ± 4.7	0.88 ± 0.02
5.0×10^{-2}	95.0 ± 5.3	65.0 ± 6.1	0.49 ± 0.2
Potassium thiocyanate			
1.0×10^{-2}	97.5 ± 3.1	82.5 ± 3.1	1.07 ± 0.3
2.5×10^{-2}	97.5 ± 3.1	60.0 ± 4.1	0.61 ± 0.2
5.0×10^{-2}	97.5 ± 3.1	37.5 ± 10.2	0.37 ± 0.2
Potassium nitrate			
1.0×10^{-2}	97.5 ± 2.5	70.0 ± 16.2	0.75 ± 3.2
2.5×10^{-2}	97.5 ± 2.5	72.5 ± 3.5	0.64 ± 0.1
5.0×10^{-2}	97.5 ± 2.5	72.5 ± 7.1	1.01 ± 0.07
Manganese sulphate			
1.0×10^{-2}	95.0 ± 2.8	72.5 ± 10.2	1.00 ± 0.2
2.5×10^{-2}	97.5 ± 2.5	75.0 ± 12.2	1.04 ± 0.2
5.0×10^{-2}	97.5 ± 2.5	72.5 ± 14.3	0.66 ± 0.2
Control			
Water	95.0 ± 5.0	72.5 ± 8.2	1.16 ± 0.3

in other solutions remained more or less the same as in the control. With 1.0×10^{-2} and 2.5×10^{-2} *M* manganese sulphate, the root lengths approached those of the control. In the remaining treatments, the root growth was lower than in the control. There was a remarkable inhibition in root growth when 5.0×10^{-2} *M* solutions of thiourea and potassium thiocyanate were supplied.

m) *Effect of coumarin in the presence of thiourea:* A study was undertaken to trace the interaction between coumarin and thiourea on germination. To start with, the desired amount of coumarin (0, 10 and 20 ppm) was loaded onto a filter paper in an ether solution. After the removal of the solvent, known concentrations (1.0×10^{-2}, 2.5×10^{-2} and 5.0×10^{-2} *M*) of thiourea were added, followed by seeds of the species under investigation. The dishes containing dispersed seeds were kept in the light and dark chambers of the germinator.

Coumarin concentrations, in the presence of thiourea, reduced germination more in darkness than in light (Table 9). The germination percentage was almost the same when 10 ppm coumarin interacted with 5.0×10^{-2} *M* thiourea. With increasing concentrations of both compounds, there was generally promotion in both light and dark conditions; all these values, however, were generally below those of the corresponding controls.

n) *Effect of light quality in the presence of chemical substances:* An experiment was run with various chemical substances (thiourea, etc.) and coloured light (blue, etc). Other factors, such as temperature (25 °C), light intensity (1,280 lux) and photoperiod (24-hr light) were identical in all the dishes.

With 1.0×10^{-2} *M* thiourea in green light, 2.5×10^{-2} *M* in white light and these two concentrations of potassium nitrate in yellow light, there was complete imbibition (Table 10).

Very low germination (10%) occurred in white light with 5.0×10^{-2} *M* potassium thiocyanate and very high germination (82.5%) in yellow light at the same concentration (Table 10). At all concentrations, blue and white light with thiourea, green light with thiourea and manganese sulphate, yellow light with potassium nitrate and manganese sulphate gave 50% or more germination. Less than 50% of the seeds germinated in blue light with 2.5×10^{-2} and 5.0×10^{-2} *M* solutions of thiocyanate and nitrate, in green light with 5.0×10^{-2} *M* solutions of thiocyanate and nitrate, in yellow light with 2.5×10^{-2} *M* concentrations of the thio salts, in red light with higher concentrations of thiourea and the highest concentration of nitrate, as well as all levels of thiocyanate and manganese sulphate, and in white light with the maxi mum concentration of thiocyanate, nitrate and manganese sulphate.

Table 9

Cassia seed germination in the presence of thiourea and coumarin

Thiourea ($\times 10^{-2}$ M)	Percentage germination							
	0		1.0		2.5		5.0	
	Light	Dark	Light	Dark	Light	Dark	Light	Dark
Coumarin (ppm)								
0	85.0	92.5	92.5	90.0	97.5	90.0	85.0	95.0
	± 8.3	± 3.1	± 3.1	± 4.1	± 3.1	± 4.1	± 8.3	± 4.1
10	70.0	95.0	35.0	7.5	70.0	12.5	52.5	57.5
	±28.8	± 4.1	± 6.1	± 0.6	±28.8	± 0.3	± 6.0	±12.0
20	75.0	75.0	52.5	22.5	55.0	12.5	82.5	30.0
	±12.2	±12.2	± 6.0	±14.3	± 8.1	± 0.3	± 9.1	± 0.6

Table 10

Imbibition (A), germination (B) and root growth (C) of Cassia

Chemical substance (M)	Light quality					
	White			Blue		
	A	B	C	A	B	C
Thiourea						
1.0×10^{2}	95.0 ±4.1	57.5 ±3.1	0.38 ±0.07	90.0 ±4.1	50.0 ±12.3	0.66 ±0.10
2.5×10^{-2}	97.5 ±3.5	67.5 ±15.3	0.82 ±0.30	92.5 ±3.1	60.0 ±8.3	0.75 ±0.20
5.0×10^{-2}	92.5 ±6.1	60.0 ±12.1	0.65 ±0.08	95.0 ±4.1	60.0 ±12.3	0.70 ±0.20
Potassium thiocyanate						
1.0×10^{-2}	95.0 ±4.1	70.0 ±8.3	0.85 ±0.03	95.0 ±4.1	52.5 ±6.0	0.46 ±0.20
2.5×10^{-2}	100.0 ±0	50.0 ±8.3	0.41 ±0.10	92.5 ±6.0	40.0 ±12.0	0.60 ±0.2
5.0×10^{-2}	97.5 ±3.1	10.0 ±8.3	0.09 ±0.03	80.0 ±4.1	20.0 ±8.3	0.30 ±0.20
Potassium nitrate						
1.0×10^{-2}	87.5 ±5.1	60.0 ±5.5	0.89 ±0.10	97.5 ±3.1	50.0 ±4.1	0.26 ±0.10
2.5×10^{-2}	95.0 ±3.8	55.0 ±6.0	0.60 ±0.10	87.5 ±3.1	47.5 ±7.0	0.38 ±0.20
5.0×10^{-2}	95.0 ±3.8	40.0 ±16.0	0.79 ±0.08	90.0 ±8.3	40.0 ±8.3	0.39 ±0.20
Manganese sulphate						
1.0×10^{-2}	92.5 ±6.1	65.0 ±4.0	0.83 ±0.40	85.0 ±14.3	67.5 ±18.3	1.07 ±0.10
2.5×10^{-2}	92.5 ±6.1	57.5 ±6.0	0.56 ±0.10	92.5 ±3.1	67.5 ±6.1	0.53 ±0.20
5.0×10^{-2}	87.5 ±3.1	40.0 ±12.0	0.44 ±0.10	72.5 ±11.0	22.5 ±6.1	0.22 ±0.20

The root lengths progressively increased in blue light with potassium nitrate, the maximum value being found at the lowest concentration of the solution (Table 10). There was a progressive decrease in root growth in blue light with manganese sulphate, in green light with both thiourea and potassium nitrate, in red light with potassium nitrate and in white light with both potassium thiocyanate and manganese sulphate. Very poor root growth was evident in white light with the lowest supply of potassium thiocyanate.

A very widespread cause of seed dormancy is the presence of a hard testa or seed coat. Such hard-coated seeds may not only be impermeable to water and exert mechanical restraint on embryo growth, but may also generate a metabolic block within the embryo itself (Crocker 1916). These dormancy characteristics are exhibited by freshly-harvested or new seeds of *Cassia sophera* and not by old seeds of this species. This is somewhat akin to the dormancy *under the influence of chemical substances and light quality*

Light quality								
Green			Yellow			Red		
A	B	C	A	B	C	A	B	C
100.0 ±0	60.0 ±8.2	0.73 ±0.10	97.5 ±3.1	55.0 ±6.1	0.32 ±0.10	95.0 ±4.1	55.0 ±8.3	0.49 ±0.20
97.5 ±3.1	67.5 ±8.2	0.55 ±0.20	90.0 ±4.1	45.0 ±6.1	0.54 ±0.1	55.0 ±32.5	35.0 ±16.0	0.59 ±0.3
97.5 ±3.1	57.5 ±19.4	0.40 ±0.30	97.5 ±3.1	72.5 ±6.1	0.51 ±0.10	95.0 ±6.1	40.0 ±8.3	0.23 ±0.1
92.5 ±6.0	77.5 ±10.3	0.51 ±0.10	97.5 ±3.1	60.0 ±4.1	0.77 ±0.10	85.0 ±4.1	40.0 ±12.5	0.39 ±0.20
92.5 ±6.0	60.0 ±16.3	0.53 ±0.10	95.0 ±4.1	55.0 ±16.3	0.79 ±0.30	90.0 ±4.1	27.5 ±3.1	0.17 ±0.20
97.5 ±3.1	20.0 ±8.3	0.30 ±0.10	97.5 ±3.1	32.5 ±7.1	0.41 ±0.3	95.0 ±6.1	17.5 ±6.0	0.20 ±0.20
97.5 ±3.0	77.5 ±6.1	1.01 ±0.70	100.0 ±0	70.0 ±8.3	1.15 ±0.10	92.5 ±6.0	52.5 ±6.0	0.57 ±0.10
90.0 ±4.1	65.0 ±8.1	0.78 ±0.20	100.0 ±0	80.0 ±4.1	0.74 ±0.30	92.5 ±3.1	50.5 ±8.3	0.44 ±0.30
92.5 ±3.1	37.5 ±15.1	0.66 ±0.10	97.5 ±3.1	62.5 ±18.2	0.86 ±0.1	77.5 ±23.3	22.5 ±14.3	0.37 ±0.20
95.0 ±6.1	65.0 ±14.0	0.75 ±0.20	87.5 ±6.1	50.0 ±4.1	0.59 ±0.10	55.0 ±8.3	22.5 ±6.0	0.23 ±0.20
95.0 ±4.1	72.5 ±14.0	1.01 ±0.10	85.0 ±8.3	60.0 ±4.1	0.60 ±0.20	66.0 ±8.3	32.5 ±7.0	0.23 ±0.10
90.0 ±4.1	72.5 ±10.3	0.56 ±0.10	92.5 ±3.1	82.5 ±14.3	0.45 ±0.10	57.5 ±9.0	22.5 ±7.0	0.17 ±0.10

mechanism in *Astragalus tennesseensis*, where the inner seed coat prevents the germination of imbibed seeds by offering mechanical resistance to the expansion and growth of the embryo, as well as by retarding the leaching of the inhibitory substance or substances from the embryo (BASKIN—QUARTERMAN 1969).

From the seed samples of *C. sophera* collected at various localities, only those from locality No. III can overcome dormancy by a period of dry storage. But the seeds from other localities will not lose dormancy as a consequence of storage unless acid-scarification is resorted to. Fresh seeds stored for 1—4 months can be induced to germinate after the application of this dormancy-breaking measure and not before it. However, one-year old seeds, with which most of the experiments in this work have been performed, seem to germinate without needing any scarification.

The aqueous extract prepared from the seeds shows a two-fold nature. It is found to promote and inhibit germination. Hence, the possibility of some water-soluble stimulator along with the inhibitor cannot be entirely ruled out. Extracts prepared under laboratory conditions usually promote the germination of old seeds when used on seeds of the same category, while the extract of new seeds causes more inhibition on new seeds than on old seeds. Inhibitors are reported in the fruits and seeds of several plants (DATTA—SINHA-ROY 1974). These inhibitors play a significant role in the imposition and maintenance of seed dormancy (VEGIS 1964). This phenomenon apparently occurs in the seeds of *C. sophera* to a certain extent.

It has frequently been stated that the interaction of temperature and light would be expressed differently in different species (TOOLE *et al.* 1957) and that temperature would act by a mechanism quite distinct from that of light (KOLLER *et al.* 1962). In the present case, a temperature of 25 °C may be considered as optimum for germination, with more seeds responding in darkness than in light using the requsite wetting agent (2 ml). The effect of high temperature stimulus is striking at 70 °C, as the technique of dry-heating enhances the permeability of the seed coats to water and accelerates the germination of the seeds. This is still conspicuous at 80 °C, although there are differential responses with the duration of the pre-treatment and the exposure to the subsequent environment. Pre-treatment temperatures of 90 and 100 °C are lethal, presumably due to injury to the embryo.

There is a low germination percentage under extreme water stress, though imbibition remains unaffected. Both germination and root growth are progressively retarded with increasing water tension. The foregoing indicates that the mere presence of liquid water in contact with the seed may not suffice for germination (KOLLER 1957), but a suitable temperature and light or dark regime must prevail for *C. sophera* seeds in order to bring about a favourable response. A case in point is another hard-seeded legume, *Aeschynomene aspera* (DATTA—SINHA-ROY 1975).

Similar to water stress, high salinity is cumulative in its effect on the germination and root growth of *C. sophera.* As the levels of salinity are gradually raised, both these processes are definitely repressed with 0.2 *M* NaCl. The seeds germinate better in the presence of lower concentrations of the salt and the high concentration serves as a germination inhibitor. The species thus shows a precise requirement for a certain salinity.

Although the seeds may be classified as aphotoblastic, a brief (10 or 20 min) light or dark treatment can improve the subsequent dark- or light-germination. While imbibition is affected by low light intensity (139 lux), the latter does not correspondingly affect either germination or root growth. Imbibition is quite high in all qualities of light, while germination is reduced in shorter wave-lengths, i.e. violet, blue and green light. Whereas white light is effective for furthering root growth, violet, green and red light are ineffective. Except for violet and green light, no other light quality affects both germination and root growth. So the seeds are sensitive to certain portions of the visible spectrum.

None of the chemical substances applied can promote seed germination. With the maximum concentration of thiourea and potassium thiocyanate, root growth is actually inhibited. The inhibition imposed by thiocyanate is still sustained when exposed to blue and green light. This particular trend is still maintained when the seeds are provided with nitrate instead of thiocyanate. In all concentrations, these two compounds are efficient germination inhibitors. However, the highest concentration of thiocyanate acts as a germination promoter under yellow light. The situation seemingly changes with the utilisation of manganese sulphate under some regions of the spectrum. Here one can find a progressive increase in the germination percentage in the presence of green and yellow light with this type of promoter. Moreover, the same light quality can either promote or inhibit root growth in conjunction with different chemical compounds. Thus, blue light promotes root growth when supplied with potassium nitrate as the wetting agent and inhibits root length when combined with manganese sulphate.

Additional information on the regulation of seed germination is forthcoming from an interaction study between thiourea and coumarin. Thiourea concentrations, which cause a maximum effect in the absence of coumarin, are much less effective in the presence of coumarin. In the presence of thiourea, coumarin generally acts as a germination inhibitor and the action becomes more conspicuous in the absence of light than in the presence of light. While coumarin may interfere with the initiation and destruction of endogenous substances controlling germination, thiourea may act by changing the nature and amount of endogenous germination regulators present in the seeds (Mayer—Poljakoff-Mayber 1975).

Some adaptive value may be attached to the germination behaviour of *C. sophera.* The susceptibility of the seeds to water-logging does not allow the growth of the species in areas which remain submerged for longer periods. Though the seeds can be dispersed by water, the plants are not found along waterways and only exist in high, uncultivated lands. Due to prolonged submergence, gentle slopes are not infested by this species. On the contrary, slopes with steep gradients, where water does not stand for longer periods, are suited to the establishment of *C. sophera.* Susceptibility to water-logging has been noted in *Cassia obtusifolia*, a species occurring on waste places (Mall 1957) and *Mollugo cerviana*, which is found in dry habitats (Bakshi—Kapil 1954). Furthermore, the seeds will fail to germinate if the soil moisture falls short of 30%. A cerrain quantity of moisture (70%) will, however, ensure the maximum emergence of seedlings, as is seen during the month of April.

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Prepared at the Department of Botany, University of Calcutta, Calcutta

S. C. Datta, R. Basu

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N, P AND K REQUIREMENTS FOR THE TARGETTED YIELDS OF WHEAT (T. AESTIVUM) IN TARAI SOILS OF UTTAR PRADESH (INDIA)

Judicious use of fertilizers takes into account the fertility status as well as crop needs The fertilizer dose required to produce the desired yield targets takes into account total nutrient removal, efficiency of soil and fertilizer forms of the nutrient and their interactions as well (RAMAMOORTHY—VELAYUTHAM 1972). Fertilizer recommendations based on the targetted yield approach are considered to be suitable particularly under resource constraints. The zonal concept for such soil test crop response correlations is very well recognized (RAMAMOORTHY—VELAYUTHAM 1971). The relationship between fertilizer nutrients and soil fertility parameters has to be soil-plant-climate specific under the recommended agronomic conditions of an area. The present investigation was conducted with wheat on a widely distributed soil type, tarai, in the wheat growing belt of Uttar Pradesh.

The experiment was conducted at the Experiment Station of G. B. Pant University of Agriculture and Technology, Pantnagar (Nainital). The experimental soil was aquic hapludoll (DESHPANDE *et al.* 1971) which had a fine silty texture and is very widely distributed in the entire wheat belt of the tarai area. The experiment was conducted in two steps. Firstly, a fertility gradient stabilizing crop of fodder maize was grown after applying differential levels of N, P and K. Thus a wide variation in the fertility levels was obtained in one location only. This type of artificially created fertility variation simulates the existing variation in this well classified cultivated soil. Inherent fertility variations are only of minor importance and the soil test values differ generally due to differential fertilizer applications and soil management practices. In the second step, the response of various selected treatment combinations of 5 levels of N (0, 50, 100, 150 and 200 kg N/ha), 4 levels of P (0, 22, 44 and 66 kg P/ha) and 3 levels of K (0, 41.5 and 83 kg K/ha) to the wheat variety Kalyan Sona was studied at these fertility levels. Before applying fertilizer to the wheat, soil samples from each plot at 0—15 cm depth were collected, dried, passed through a 2 mm sieve and analysed for available N (SUBBIAH—ASIJA 1956), available P (OLSEN *et al.* 1954) and available K (HANWAY—HEIDEL 1952).

At the time of harvest, grain and straw yields were recorded and plant samples of grain and straw from each plot were collected. The grain and straw samples were dried, ground and analysed for N, P and K by the methods described by PIPER (1966). Whereas all the plant samples from the control plots were analysed, only a restricted number of plant samples from the treated plots were taken for analysis. It was restricted to the samples from the plots up to which almost linear response to various levels of N, P and K taken separately was observed. The nutrient uptake for producing specified grain yields and efficiency factors for soil and fertilizer nutrients were utilized to develop equations of the following type:

$$F_{(\text{nutrient})} = [(YT \times A) - (STV \times B)] \frac{100}{C} \tag{1}$$

where,

$F_{(\text{nutrient})}$	=	Fertilizer requirement (nutrient kg/ha)
YT	=	Grain yield target (q/ha)
A	=	Total nutrient uptake (grain + straw) to produce one quintal of grain
STV	=	Soil test value
B	=	Factor for contribution of nutrient from the soil
C	=	Fertilizer use efficiency (%)

In equation (1), A was obtained by dividing the total uptake of nutrient by the grain yield recorded in the individual plot; B was calculated by relating the total uptake to its soil test value in the control plot and C was worked out by first computing the expected nutrient contribution from soil test values and then subtracting the same from the total uptake in that treated plot, and finally the fertilizer efficiency was calculated from the additional nutrient uptake due to a known amount of the nutrient added.

The mean values in respect of total nutrient uptake for producing 1 q wheat grain were 2.49, 0.29 and 2.70 kg of N, P and K respectively. The contributions of nutrient from the soil in the control plots were found to be 27.4%, 28.6% and 75.8% of alkaline $KMnO_4$-N, Olsen's P and ammonium acetate K, respectively. Taking these values to hold true in the case of the treated plots as well (which is theoretically incorrect but practically immaterial for the final calculation of fertilizer doses), the contributions from added fertilizer were found to be 36.4%, 19.6% and 82.12% for N, P and K, respectively. Since the priming effect is compounded, there was generally an under-estimation of the contribution of nutrients originating from the soil in the treated plots. Likewise, the contribution originating from the fertilizer is over-estimated. However, when these data are arranged in the form of equation 1 the discrepancy is evened out and the following set of simplified equations was obtained for N, P and K, respectively:

$$\text{Fertilizer N (kg/ha)} = 6.84 \times YT - 0.75 \times \text{available N (kg/ha)} \tag{2}$$
$$\text{Fertilizer P (kg/ha)} = 1.48 \times YT - 1.45 \times \text{available P (kg/ha)} \tag{3}$$
$$\text{Fertilizer K (kg/ha)} = 3.26 \times YT - 0.91 \times \text{available K (kg/ha)} \tag{4}$$

Since the fertility range in the experimental plot was 200 to 500 kg available N, 10 to 50 kg available P and 125 to 200 kg available K per hectare and the yields obtained ranged from 30 to 60 q/ha, the equations could be used only within these limits. Minor deviations in the extremes are expected because of the non-linearity of the response curve in such cases.

To judge the validity of these equations, follow-up trials were carried out in two succeeding crop seasons and the results of these trials are summarized in Table 1. A perusal of the results of the follow-up trials indicates that at almost all the locations the targetted yields were obtained within $\pm 12.5\%$. This shows that these equations could be profitably used in this soil for the wheat Kalyan Sona within the specified range of soil test values and yield levels and standard agronomic practices.

Table 1

Results of the follow-up trials

Location	Soil test values (kg/ha)			Tar-getted yield, q/ha	Nutrient required (kg/ha)			Yields actually obtain-ed	Yield deviation (%)
	Alkaline $KMnO_4$-N	Olsen's P	Ammonium acetate-K		N	P	K		
				Year 1973–74					
I	225	30	200	40	104	15.7	0	43.2	+ 8.0
				50	173	30.5	0	51.3	+ 26.
II	350	20	150	40	30	30.2	0	37.0	— 7.5
				50	79	45.0	26.5	48.9	— 2.2
III	425	40	175	40	0	1.2	0	37.6	— 6.0
				50	22	16.0	3.75	46.9	— 6.2
				Year 1974–75					
I	300	25	190	40	48	22.95	0	42.2	+ 4.4
				50	116	37.75	0	52.0	+ 4.0
II	250	32	140	40	86	12.80	3.00	36.7	— 8.25
				50	154	27.60	35.60	51.1	+ 2.2
III	225	18	170	40	104	33.10	0	45.0	+12.5
				50	178	47.90	8.30	53.6	+ 7.2
IV	325	28	150	40	29	18.60	0	36.2	— 9.5
				50	98	33.40	26.50	46.8	— 6.4

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Prepared at the Department of Soil Science G. B. Pant University of Agriculture and Technology, Pantnagar Distt. Nainital

R. S. Sachan, N. Ram, K. Singh, B. Ram, R. A. Gupta

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PHOTOPERIOD IN RELATION TO THE DEVELOPMENT AND REPRODUCTION OF THE ERISILKWORM PHILOSAMIA RICINI BOISD.

The erisilkworm *Philosamia ricini* Boisd., may well become a source of silk in Egypt beside the silkworm *Bombyx mori* L.

Most of the work on the effect of photoperiodism on the development and diapause of silkworms has been carried out on *Bombyx mori* L. (KOGURE 1933, MEGALLA 1974), the Tussar silkworm, *Antheraea mylitta* (JOLLY *et al.* 1971) and the Chinese silkworm, *Antheraea pernyii* (TANAKA 1950). TANAKA (1950) found that the onset of pupal diapause in *A. pernyii* was under photoperiodic control. Also WILLIAMS—ADKISSON (1964) stated that photoperiod has been shown to control not only the onset of pupal diapause but also its termination.

From biological studies on the erisilkworm *Attacus ricini* carried out by GOMAA (1973a, b) it was found that a temperature of 25°C was the optimum for development and egg production. ALI—SALEM (1977) mentioned that the food consumption, digestion and growth of larval instars of *Ph. ricini* were photoperiodic dependent, and a 10 hour photophase was the most favourable for insect development.

Since the daylength in Egypt ranges from 14 hours on June 17th (the longest day) to 10 hours on December 21st (the shortest day), the insects are thus exposed to a wide variation in daylength. As photoperiodism is known to be a regulating factor in insect development, it was felt necessary to study the effect of different photoperiods on the developmental rate and silk production of the multivoltine erisilkworm *Ph. ricini* in order to find the most favourable photoperiod for the rearing of this insect.

Larvae of the erisilkworm, *Ph. ricini*, were raised in $20 \times 15 \times 8$ cm wooden boxes with two circular openings 3 cm in diameter on two sides of the box, each covered with muslin for ventillation. The boxes were covered with framed sheets of fine muslin. Twenty newly hatched first instar larvae were reared in each box. The larvae were fed with fresh leaves of the castor plant *(Ricinus comunis)* of the green variety. These leaves were thoroughly washed and dried before being fed to the larvae. The castor leaves were renewed and the faeces were discarded every 24 hours. When the larvae reached the end of the fifth instar, fine branches of caswarina were placed in the rearing boxes to provide pupating sites.

The rearing conditions were as follows: temperature 25 °C (± 1 °C); photoperiods (light per dark): 0/24, 10/14, 11/13, 12/12, 13/11, 14/10 and 24/0 hours. The cooling—heating incubators containing the rearing boxes were supplied with photoboxes ($47 \times 40 \times 40$ cm) which were illuminated by 40 W fluorescent lamps. The duration of the light period was automatically controlled by an electric light-timer.

The rearing units and their contents were examined daily. Larval duration, larval mortality and pupal duration were recorded. When the larvae had spun cocoons, twenty cocoons from each photoperiodic treatment were opened seven days after spinning and were

Table 1

Mean durations of immature stages of Philosamia ricini Boisd. when reared at a constant temperature (25 °C) with different photoperiods

Photoperiod light/dark (hrs)	Mean duration of larval instars in days					Mean duration of pupal stage (days)	Mean duration of pupal stage (days)	Mean total developmental time (days)
	I	II	III	IV	V			
L/D								
0/24	5.0±0.5	4.0±0.0	3.0±0.0	9.7±0.9	8.4±0.3	5.9±0.3	17.7±0.9	53.7±1.2
10/14	4.0±0.0	5.0±0.0	5.0±0.0	8.3±0.3	8.7±0.7	4.4±0.7	13.3±0.3	48.7±0.7
11/13	5.7±0.7	4.7±0.3	4.7±0.3	8.7±0.7	8.3±0.3	3.3±0.1	14.6±0.9	50.0±2.1
12/12	4.3±0.3	4.3±0.3	6.3±0.7	8.3±0.3	9.0±1.6	3.3±0.5	17.0±0.5	52.5±1.8
13/11	4.7±0.3	4.7±0.3	6.3±0.7	8.0±0.5	9.3±0.7	4.0±0.4	18.0±1.0	55.0±1.0
14/10	4.3±0.3	5.3±0.3	5.3±0.3	8.7±0.3	9.3±0.3	5.0±0.2	17.7±0.9	55.6±0.9
24/ 0	5.0±0.5	5.3±0.3	6.0±0.0	8.7±0.3	8.3±0.7	5.0±0.7	17.3±0.3	55.3±1.2

L = Light Total developmental time: F between photoperiods, 3.444,
D = Dark L.S.D. 0.05 between photoperiods: 4.08.

sexed. Female and male pupae, as well as cocoons were freshly weighed. The weights of newly emerged female and male adults were also recorded.

Effect of photoperiod on the duration of immature stages. The durations of the different instars showed stage-dependent changes in response to the photoperiods tested. The rate of growth at a given instar, as shown in Table 1, could be partially controlled by the photoperiods tested. The most accelerated development was found in the first, second, third, fourth and fifth instars by using 10, 0, 0, 13 and 11 hour photoperiods respectively. The most retarded development was observed for 11, 24, 24, 0 and 14 hour photoperiods in the first, second, third, fourth and fifth instars respectively (Table 1). The statistical treatment of the data obtained showed that significant differences prevailed between the averages obtained.

However, the total duration of the larval stage gradually increased with the increase in the photoperiod, as follows: 30.1, 31.0, 32.1, 32.2, 33.0, 32.9 and 33.9 days by using 0, 10, 11, 12, 13, 14 and 24 hour photophases respectively. Thus, from the standpoint of growth rate, rearing the larvae of *Ph. ricini* under scotophase conditions may result in the most accelerated development (Table 1).

With regard to the duration of the prepupal and pupal stages, the trend observed in the larval stage was reflected for the most part, except that the prepupae and pupae of larvae reared under scotophase conditions showed retarded development. It could be concluded that the duration of the larval stage was prolonged by an increase in the photoperiod and the shortest duration was found in complete darkness. The prepupal, pupal and post embryonic periods showed the same tendency but the shortest durationwas encountered using a 10 hour photophase in the larval stage. The statistical treatment of the data obtained showed that significant differences prevailed between the averages.

It must be recalled that the effect of the photoperiods tested on the prepupal and pupal stages was only due to their effect on the larvae as in both stages all the individuals passed these stages in complete darkness wrapped in their cocoons.

Effect of photoperiod on mature stage. The pre-oviposition and oviposition periods, the longevity of the adults and the mean number of eggs laid per female, as physiological functions, showed an interaction with the exogenous stimuli brought about by using different light regimes during the larval stage.

Larvae reared under a photophase of 13 hours per day yielded silkworms which showed the longest pre-oviposition period, the shortest oviposition period, the least male longevity and the least eggs laid per female (Table 2). However, the longest oviposition period, the longest longevity of adults and the highest mean number of eggs laid per female were observed for adults from larvae reared under a 10 hour light regime.

Effect of photoperiods on silk production, on weights of pupae and adults. Weight of female and male cocoons could be considered the over-all efficiency of the larval organ, the silk gland. The weight of male and female pupae and adults could also be considered as the final growth of the individuals.

Table 2

Effect of photoperiod on the oviposition period, adult longevity and the fecundity of mated females of Philosamia ricini Boisd. at 25 °C

Photoperiod (light/dark) (hours)	Mean duration of periods (days)		Mean adult longevity (days)		Mean No. of eggs/female
	Pre-oviposition	Oviposition	Female	Male	
L/D					
0/24	2.9 ± 0.01	3.0 ± 0.04	8.1 ± 0.07	8.0 ± 0.04	219.0 ± 47.6
10/14	3.6 ± 0.02	3.6 ± 0.03	10.4 ± 0.03*	9.4 ± 0.03*	421.5 ± 78.0*
11/13	3.9 ± 0.00	3.1 ± 0.07	8.4 ± 0.09	8.0 ± 0.05	180.0 ± 40.0
13/11	4.3 ± 0.05*	2.3 ± 0.00	7.5 ± 0.05	7.2 ± 0.50	171.0 ± 36.6
14/10	3.0 ± 0.00	3.0 ± 0.04	7.0 ± 0.04	7.3 ± 0.4	224.3 ± 56.7

* Significant differences.

Table 3

Mean fresh weight (mg) of pupa, cocoon and adult of the erisilkworm Ph. ricini Boisd. under the influence of different photoperiods

Photo-period Light/dark (hours)	Weight of coccons (mg)		Weight of pupa (mg)		Weight of emerged moth (mg)	
	Female	Male	Female	Male	Female	Male
L/D						
0/24	213.3±41.3	212.4±17.8	1841.3± 91.1	1570.0±109.1	1190.8± 33.4	586.8± 42.1
10/14	296.7±37.9	217.6±24.7	1950.0± 71.5	1643.9±106.5	1231.0± 26.0	654.6± 37.5
11/13	206.3±71.2	179.4±11.5	1887.3± 92.1	1523.0± 95.7	1078.2±105.1	644.2± 28.3
12/12	147.9± 4.6	164.2±14.8	1563.5± 75.1	1496.2± 43.7	954.7± 22.4	510.9± 7.5
13/11	201.3±43.2	163.0±13.6	1521.0±154.8	1470.0± 46.7	834.4± 36.2	524.1± 8.3
14/10	194.6±24.5	165.9±13.2	1564.6±105.0	1420.0± 97.2	865.0± 6.4	417.4±109.1

As shown in Table 3, all these weights, as criteria of physiological involvement which are endogenously controlled, showed an interaction with the exogenous stimuli brought about by using different light regimes throughout the larval stage.

It could be concluded that the weights of cocoons, pupae and adults were higher when using short photoperiods (10 and 11 hours) or complete darkness than when using long photophases (12, 13 or 14 hours). It may be of interest to note that of all the photoperiods tested, the 10 hour photophase, which showed the most accelerated postembryonic development, produced the highest weights. Also, by using complete darkness throughout the larval stage, which showed the most accelerated larval development, the resultant weights of cocoons, pupae and adults ranked next to those of thw 10 hour photophase (Table 3).

Little is currently known about the specific physiological mechanism by which photoperiod stimuli influence the growth rate and growth. It was shown by ALI—SALEM (1977) with the same insect *(Ph. ricini)* that the photoperiod produces specific effects on the food consumption and consequently on the digestion and growth of larvae.

In the present work, the photoperiods tested were shown to exert specific effects on growth rate of immature stages, pre-oviposition period, oviposition period, adult longevity, fecundity, and weights of cocoons, pupae and adults of *Ph. ricini*. A short photoperiod, especially 10 hours per day, proved to be mostly favourable for all these aspects. This seems to indicate that *Ph. ricini* is a short day insect and consequently resembles its close relatives (KOGURE 1933, WILLIAMS—ADKISSON 1964, MEGALLA 1974).

According to the findings of GEISPITZ—ZARANKINA (1963) and DANILEVSKII (1965), the caterpillar species differ markedly in the effect of daylength on growth rate and growth, with some being activated and others inhibited by long days. It can thus be concluded that the photoperiods affected the developmental rate of immature stages, pre-oviposition period, oviposition period, adult longevity, number of eggs laid per female and weight of cocoons, pupae and adults of *Ph. ricini*, as shown by GOMAA (1973a, b) with the same species and MEGALLA (1974) with the silkworm *Bombyx mori* L.

It may be concluded that the photoperiods tested were of no biological significance in the larval stage but that they exerted an after-effect in the prepupal, pupal and adult stages which seems to accord with the after-effect of photoperiodism in the diapausing eggs of *Bombyx mori* L. (KOGURE 1933) or pupal diapause in *Antheraea pernyii* (TANAKA 1950) and *A. mylitta* (JOLLY *et al.* 1971).

It could be generally concluded that the conditions of photophase which were favourable for more accelerated development were also favourable for growth when expressed in terms of weights of cocoons, pupae and adults, as well as for egg production. Thus, the erisilkworm *Ph. ricini* may be considered as a short day insect.

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Prepared at the Plant Protection Department, Faculty of Agriculture, Al Azhar University, Cairo, Plant Protection Department, Faculty of Agriculture, Cairo University, Giza

M. A. ALI, M. S. SALEM

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GERMINATION AND SEEDLING GROWTH OF VARIOUS CROP SEEDS AS INFLUENCED BY DIFFERENT GROWTH MEDIA*

Various techniques have been used for growing plants at the germination and early developmental stages depending upon the requirements of the study on hand and the convenience of the workers. However, no standard methods have so far been set up to achieve the best growth under a given set of conditions. When filter papers were used as germination media they either inhibited it (REHWALDT 1968) or gave erratic results (YOUNIS—HATATA 1971). It was therefore considered worthwhile first to standardize the technique for studying growth at early growth stages and then to use this in later studies. Wheat was taken as the test crop and the method found to be comparatively better was later tried on various other crops to confirm the findings.

a) *Comparison between various growth media.* Petri dishes 10 cm in diameter and beakers with a capacity of 250 ml (standard pyrex glass) were used, and the growth media tested are given in Table 1.

Seeds of wheat, *Triticum aestivum* cv. H-68, were treated with a fungicide (Agroson) prior to planting at the rate of 20 seeds per treatment, arranged in a circle, grooved side down, with the embryos pointing outwards. All the treatments were covered with Petri dishes to avoid evaporation during the course of the experiment. These were kept in complete darkness in a germinator maintained at 26 $\pm$ 2 °C and 100% relative humidity according to a completely randomized design with three replicates. Seeds were considered to have germinated when they exhibited a coleoptile growth of 5 mm. Observations on shoot, root length and germination were made 120 hr after planting. The experiment was repeated on five different occasions with identical treatments and the overall average was calculated.

b) *Comparison between various crops.* The method found to have given the best growth in wheat seedlings was later tried on cotton, *Gossypium hirsutum* cv. M-100; sunflower, *Helianthus annuus* cv. Mayak; safflower, *Carthamus tinctorius* cv. Gila; pea, *Pisum sativum* cv. Early Dwarf; gram, *Cicer arietinum* cv. Sanyasi; maize, *Zea mays* cv. Goudster; barley, *Hordeum vulgare* cv. Himalya and rice, *Oryza sativa* cv. D.B-198, following exactly the same

* Part of the research submitted by the senior author as a requirement for an M. Phil degree from the University of Sind.

procedure as that used for wheat. This was done to ascertain the suitability of the best method of growth for other crops.

c) *Loss in weight due to evaporation.* In order to calculate the loss in weight due to evaporation, beakers containing 50 ml of 0.75% agar gel along with 0.6 and 1.0% NaCl were weighed again after 120 hr and the loss in weight was calculated.

a) *Comparison between various growth media.* Wheat growth on fourteen different growth media showed that the best seedling performance was achieved on agar gel, while plants grown on one sponge in a Petri dish with 15 ml water or on two sponges in a beaker with 30 ml water gave the poorest growth (Table 1). A though there were minor variations in plant height at the various times when the experiment was repeated, the above observation always held good. However, the germination percentage was not affected by the growth media and satisfactory (above 85%) germination was a ways observed (Table 1).

b) *Comparison between various crops.* An experiment was also conducted to study the germination and early seedling growth of various crops in the best (0.75% agar gel) and the next best (50 ml water + 2 sponges + 1 filter paper) media. Five summer crops (cotton, sunflower, safflower, maize and rice) and four winter crops (peas, gram, barley and wheat) were studied and it was observed that here again 0.75% agar gel proved its superiority over the other growth medium (Table 2). The growth of cotton and peas was not good in either of the media, so they are not suited for studying under these conditions. The growth of all other crops was better in 0.75% agar gel and barley seed did not germinate at all in the other growth

Table 1

Effect of various growth media on wheat, cv. H-68

No.	Growth medium	Germination (%)	Height (cm)
1.	Petri dish + 3.5 ml water + filter paper	98	4.18d
2.	Petri dish + 7.0 ml water + filter paper	87	4.97c
3.	Petri dish + 15 ml water + sponge	91	2.29f
4.	Petri dish + 25 ml water + sponge	97	4.68d
5.	Petri dish + 12.5 ml water + 70 g sand	96	4.84cd
6.	Beaker + 3.5 ml water + filter paper	96	4.00d
7.	Beaker + 7.0 ml water + filter paper	92	5.56bc
8.	Beaker + 30 ml water + 2 sponges	89	2.01f
9.	Beaker + 30 ml water + 2 sponges + filter paper	94	3.37e
10.	Beaker + 40 ml water + 2 sponges	97	4.12d
11.	Beaker + 40 ml water + 2 sponges + filter paper	99	4.10d
12.	Beaker + 50 ml water + 2 sponges	98	5.59bc
13.	Beaker + 50 ml water + 2 sponges + filter paper	98	6.09b
14.	Beaker + 12.5 ml water + 70 g sand	95	5.95b
15.	Beaker + 50 ml of 0.5% agar gel	98	9.04a
16.	Beaker + 50 ml of 0.75% agar gel	99	9.75a

In the vertical columns figures followed by the same subscript are not significant at the 5% level.

The data regarding germination are not statistically different from one another.

medium. With the exception of maize and wheat, there was always a tendency towards a decrease in the germination percentage of the crop seeds with a change in the growth medium from agar gel to sponge. The decrease was more pronounced in the case of gram, peas and safflower.

c) *Loss in weight due to evaporation.* Evaporation during the course of the experiment results in an increase in the salt concentration of the growth medium, thus fiving erratic results. From the data of the experiments to calculate the loss in weight due to evaporation, it was observed that the loss was negligible (Table 3). It was thus concluded that experiments sould safely be conducted in 0.75% agar gel without any fear of an appreciable change in the salinity level up to five days.

This study was felt necessary because results based on plants which do not have satisfactory growth are not reliable. Such plants might have an abnormal metabolism and any changes brought about by additional salinity treatments or by other means could not be well defined and might further confuse matters.

It was generally observed that, except in the case of agar gel, the seedlings had difficulty in finding an anchor, so water availability may have been severely affected. The fact that availability of water played a vital role was evident in other treatments as well, where there was already less water present in the system, and where reduced plant growth was exhibited (Table 1).

Growth in Petri dishes was not satisfactory, probably because the dishes had to be kept covered to avoid moisture loss during the course of the experiment, thus checking the normal growth of the seedlings. This can clearly be seen by comparing treatments No. 5 and 14 (Table 1), where the only difference is the container in which the seeds were grown. Thus it could be deduced that if only germination is to be studied the container does not matter

Table 2

Effect of growth medium on various crops

Crop	0.75% agar gel		Sponge + 50 ml water		Mean[1]	
	Height (cm)	Germination (%)	Height (cm)	Germination (%)	Height (cm)	Germination (%)
Cotton	2.57	63	1.68	58	2.13e	60.5e
Sunflower	4.30	83	2.67	85	3.49d	84.0c
Safflower	3.65	95	1.71	88	2.68e	91.5bc
Peas	2.22	95	2.33	83	2.28e	89.0c
Gram	3.54	88	3.08	55	3.31d	71.5d
Maize	9.33	100	8.51	100	8.92b	100.0a
Barley	4.58	53	—	—	2.29e	26.5f
Rice	6.47	98	5.27	94	5.87c	96.0b
Wheat	10.98	100	7.55	100	9.27a	100.0a
Mean[2]	5.29	86	3.07	74	—	—

[1] Means for comparing crops.
[2] Means for comparing the growth media.
In the vertical columns values followed by a similar subscript are not significant at the 5% level.

Table 3

Loss in weight (%) of growth medium due to evaporation during the course of the experiment

Salinity (%)	Replicates			Average
	1	2	3	
0.0	0.292	0.297	0.295	0.294
0.6	0.298	0.250	0.360	0.303
1.0	0.268	0.354	0.383	0.335

but if proper growth is also desired there should be ample space for the seedlings to grow normally without any hindrance. It is possible that beyond 120 hr of growth the 250 ml beaker might also prove to be an imperfect container and a longer one may be needed. However, in the present studies the experiments were terminated before the seedlings touched the covers, so 250 ml beakers were found to be satisfactory.

The use of sponge was also not desirable, since the roots became entangled in the pores and also with one another. Hence intact roots could not be obtained for observing the length and number of rootlets, etc. Placing a filter sheet over the sponge prevented the roots from entering the sponge pores, but here too the roots spread over the filter paper and it was not easy to separate them, while many of them crept down the sides and again could not be separated. In the case of agar gel, the seedlings could easily be pulled out without breaking any portion and could thus be properly observed. The superiority of agar gel was further confirmed when it was used to germinate seeds from various crops. The seeds of all crops grew better in agar gel, with the exception of cotton and peas, which did not exhibit proper growth in agar gel but were even worse on sponge (Table 2).

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Prepared at the Atomic Energy Agricultural Research Centre, Tandojam, Department of Botany, Sind University, Jamshoro

R. Ansari, S. M. Naqvi, S. A. Ala

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ORGANIC AND TOTAL PHOSPHORUS IN RELATION TO SOIL PROPERTIES IN SOME SOILS OF NORTH-WEST INDIA

The amount of organic and total phosphorus in soils gives an indication of their capacity to supply phosphorus to plants (Black 1973, Wild 1958). An examination of the reported determination of total P in some soils in Australia (Piper 1938), New Zealand (Walker—Adams 1959), Finland (Kaila 1963a), Hungary (Fabri 1963) and North America (Robinson 1917) reveals a wide variation in its content ranging from 87 to 2080 ppm. A significant proportion of the phosphorus present in soils is in organic combination. The organic P comprised between 20—80% of the total P in some soils of Australia and New Zealand (Williams—Steinbergs 1958, Wells—Saunders 1960), whereas it constituted 17—68%, 1.8—77.7% and 10—79% of the total P in the soils of Finland (Kaila 1963b) and Nigeria (Enwezor 1967), respectively. Most of the soils of North-West India which are sown to wheat and rice crops and give an acidic reaction, are reported to be phosphate deficient (Sharma—Bhumbla 1975). There is a lack of scientific information on the distribution of total and organic phosphorus in these soils. The dependence of organic and total P on various soil factors seems to differ between various soils. The present investigation was undertaken to obtain information on the amount and distribution of organic and total phosphorus in relation to the physico-chemical parameters of some soils of North-West India.

Seventy soil samples were collected from different soil zones of Himachal Pradesh in North-West India representing seven profiles and thirty three surface soils in order to study the content and distribution of organic and total P. A brief description of the soils, given by Bhumbla *et al.* (1966), is as under:

1. Non-calcic brown soils: These soils include the areas of the Kulu valley and the adjoining hills with an annual average rainfall ranging between 1000—1500 mm. They are acidic to slightly acidic in reaction and are rich in organic matter and low in available P. The soils have developed under temperate, sub-humid forested conditions. They are matured soils. Wheat, maize, rice, apples, peaches and plums are the crops grown on these soils.

2. Grey-brown podzolic soils: These soils include the areas of the Palampur and Kangra tehsils in Himachal Pradesh. The average annual rainfall is more than 1500 mm. The soils are acidic in reaction as well as having high P-fixing capacities and a deficiency of P, Ca and Mg. These soils have developed under temperate humid and coniferous vegetation, and are matured. Wheat, maize, rice, linseed, potato and tea are the major crops grown on these soils.

3. Reddish chestnut soils: These soils constitute the areas of the Dehra, Nurpur and Hamirpur tehsils in Himachal Pradesh. The average annual rainfall is 750—1000 mm. The soils are mildly acidic to slightly alkaline in reaction. They are deficient in available nitrogen, phosphorus and potash. The soils have developed from materials of more recent origin under semi-arid deciduous vegetation. Wheat, maize and sesame are the main crops.

The soil samples were air dried, ground and passed through a 2 mm sieve. The pH was measured with a Beckman pH meter using a 1 : 2 soil : water ratio. Clay was determined by the International Pipette method. Oxidizable organic matter and Total P were determined according to the standard procedures described by Jackson (1958), while organic P was determined by the method of Mehta *et al.* (1954). The statistical analysis was done by the methods outlined by Snedecor (1946).

The data on pH, organic matter, clay, total and organic P in the profile and surface samples of non-calcic brown, grey-brown podzolic and reddish chestnut soils are presented in Tables 1—3. Coefficients of correlation of organic and total P with soil properties are given in Table 4. The mean distribution of total and organic P in the soils is presented in Figs 1 and 2. The depthwise distribution of organic and total P is presented in Figs 3 and 4, while their relationship with organic matter and clay is shown in Figs 4 — 6. A perusal of the data

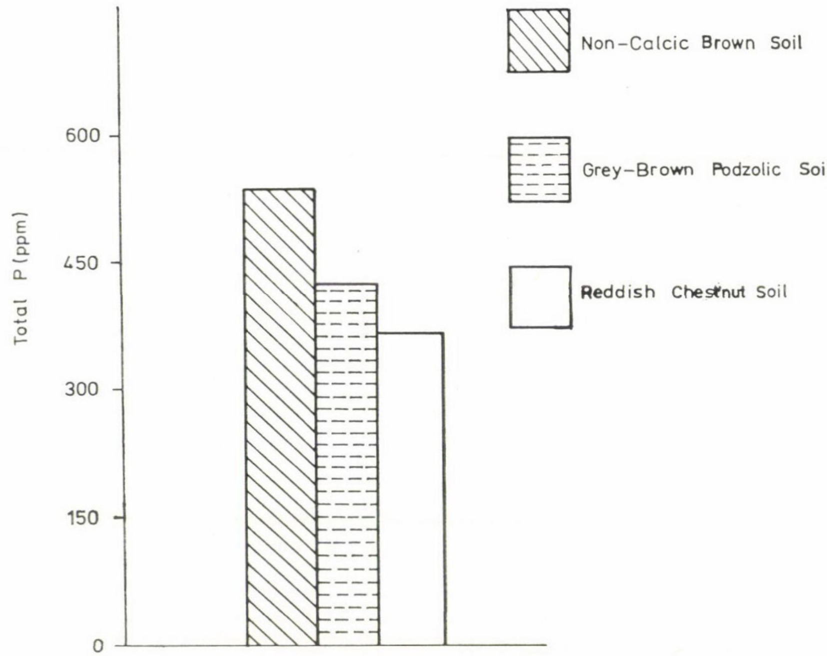

Fig. 1. Mean distribution of total P in non-calcic brown, grey-brown podzolic and reddish chestnut soils

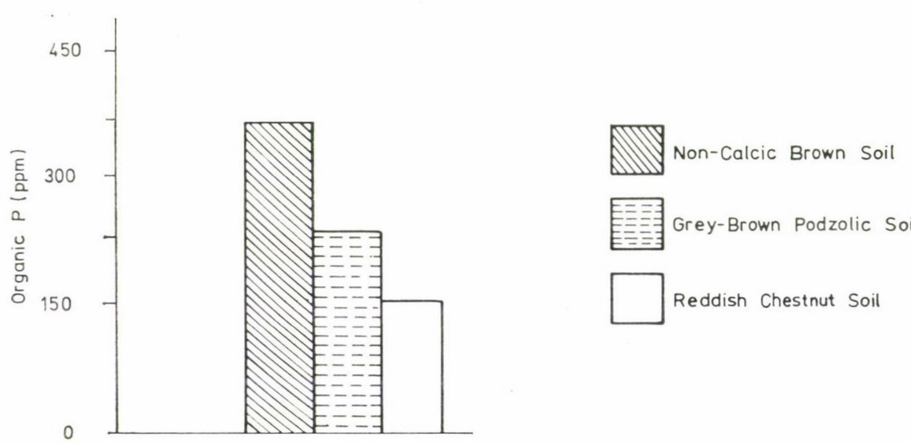

Fig. 2. Mean distribution of organic P in non-calcic brown, grey-brown podzolic and reddish chestnut soils

presented in Table 1—3 indicates that the amount of total P in the profile and surface samples of non-calcic brown, grey-brown podzolic and reddish chestnut soils ranged from 312.5 to 907 ppm, 244 to 695 ppm and 218.7 to 687 ppm with average values of 533.4, 421.8 a 361.5 ppm (Fig. 1). The organic P in the non-calcic brown, grey-brown podzolic and reddish chestnut soils varied from 192.5 to 687.5, 92 to 525 ppm and 19.2 to 487 ppm, constituting

Table 1

Soil properties, total and organic P of non-calcic brown soils

	Depth, cm	pH	Organic matter, %	Clay, %	Total P, ppm	Organic P, ppm	Organic P as % of total P
Profile 1							
Kulu	0— 17	6.6	2.30	28.0	656.2	509.7	77.7
	17— 35	6.6	1.59	27.4	505.0	371.5	73.6
	35— 65	6.7	1.57	26.4	480.0	369.5	76.8
	65— 80	6.7	1.48	25.4	468.7	366.7	78.2
	80— 90	6.7	1.47	24.6	437.5	335.0	76.6
	90—120	6.6	1.44	24.0	437.5	325.0	74.3
	>120	7.0	1.40	23.6	312.5	192.5	61.6
Surface							
Katrain	0— 15	6.5	0.57	23.5	500.0	243.7	48.7
Rupru	0— 15	6.7	4.14	26.1	907.7	687.5	75.7
Bhuntar	0— 15	7.3	1.26	20.0	468.2	210.7	45.0
Bajaura	0— 15	7.4	1.27	28.4	562.5	350.0	62.2
Manali	0— 15	6.1	2.84	30.0	636.2	262.5	41.3
Profile 2							
Barot	0— 20	6.5	2.22	26.8	602.5	400.5	66.5
	20— 45	6.0	1.27	24.8	531.2	377.7	71.1
	45— 60	6.0	1.20	23.2	500.0	364.0	72.8
Surface							
Kathiara	0— 15	6.4	3.05	25.4	593.7	375.0	63.2
Multhan	0— 15	6.5	2.53	22.6	468.7	206.2	44.0
	Average	6.6	1.86	25.3	533.4	349.8	65.2

about 41.3 to 78.2%, 27.9 to 77.6% and 7.7 to 82.9% respectively of the total P. The average amount of organic P in these soils was found to be 349.8, 235 and 161.2 ppm (Fig. 2), which comprised 65.2%, 52.4% and 40.6% of the total P. The behaviour of organic P and total P with depth (Tables 1—3, Figs 3, 4) reveal that the total and organic P decreased with depth in all the profiles under study. However, a sharp decline was observed in the Kulu, Kangra, Nurpur and Dehra profiles as compared to the Barot, Palampur and Hamirpur profiles, where it was gradual. The lower layers contained less total and organic P than did the upper ones. There appears to be little or no downward movement of either total or organic P in these soils. The relationships of organic and total P with pH, organic matter and clay were worked out through simple correlation coefficients which are given in Table 4. It was observed that organic P was significantly negatively correlated with pH while it showed a significant positive correlation with organic matter, clay and total P. The total P had a significant negative association with pH and a significant positive relationship with organic matter and clay.

Table 2

Soil properties, total and organic P of grey-brown podzolic soils

	Depth, cm	pH	Organic matter, %	Clay, %	Total P, ppm	Organic P, ppm	Organic P as % of total P
Profile 3							
Palampur	0— 20	5.9	2.33	26.5	593.7	409.0	68.9
	20— 30	5.5	2.02	24.8	500.0	329.0	65.8
	30— 40	5.6	1.81	24.0	468.0	290.0	61.9
	40— 55	5.7	1.55	22.6	437.0	262.0	60.0
	55— 80	5.7	1.33	20.8	406.0	223.0	54.9
	80—100	5.7	0.78	19.2	352.7	184.2	52.2
Surface							
Chachian	0— 15	5.9	3.36	28.2	625.0	485.0	77.6
Andretta	0— 15	4.9	2.02	25.4	500.0	335.0	67.0
Bhawarna	0— 15	5.7	1.29	13.0	352.0	98.2	27.9
Lambagaon	0— 15	6.5	3.35	18.4	468.0	262.0	56.0
Alampur	0— 15	5.6	1.81	15.2	437.0	187.0	42.8
Baijnath	0— 15	4.8	4.14	30.4	695.0	525.0	75.5
Profile 4							
Kangra	0— 15	5.9	1.40	20.4	406.2	225.2	55.4
	15— 30	6.1	1.29	18.2	281.2	116.2	41.3
	30— 47	6.1	1.28	18.0	281.2	114.2	40.6
	47— 70	6.4	0.83	18.0	256.6	111.6	42.0
	70—100	6.3	0.83	15.4	250.0	92.5	37.0
	100—120	6.3	0.82	14.8	244.0	92.0	37.7
Surface							
Nagrota	0— 15	5.3	2.12	17.6	406.0	131.0	32.2
Daulatpur	0— 15	6.2	1.60	14.6	250.0	92.5	37.0
Dharamshala	0— 15	6.2	2.53	15.4	437.0	255.7	58.5
Ichhi	0— 15	5.9	2.02	24.2	481.0	268.5	55.8
Shahpur	0— 15	6.0	1.98	25.4	487.5	243.7	50.0
Matour	0— 15	5.9	1.75	21.6	500.0	307.2	61.4
	Average	5.8	1.84	20.5	421.8	235.0	52.4

In a multivariate regression analysis, it was found that the pH, clay and organic matter together could explain 99% of the variation in the total P, whereas only 50% of the variation in organic P could be explained by these factors. The rest of the variation in organic P must be due to other factors. Two regression equations were derived when the effects of three independent variables (organic matter, pH and clay) were considered simultaneously on total and

Table 3

Soil properties, total and organic P of reddish chestnut soils

	Depth, cm	pH	Organic matter, %	Clay, %	Total P, ppm	Organic P, ppm	Organic P as % of total P
Profile 5							
Nurpur	0— 10	7.5	2.07	18.2	406.0	180.0	44.3
	10— 20	7.7	1.55	18.0	281.0	73.0	25.8
	22— 35	7.6	1.27	18.0	265.6	54.0	20.3
	35— 45	7.4	0.88	15.6	250.0	48.0	19.2
Surface							
Trilokpur	0— 15	8.1	1.50	15.8	352.0	130.0	36.9
Kotla	0— 15	8.1	2.02	16.0	437.0	312.0	71.4
Bhadwar	0— 15	6.5	0.67	14.4	250.0	19.2	7.7
Jhonta	0— 15	5.9	1.55	16.0	312.0	77.0	24.7
Profile 6							
Dehra	0— 25	7.7	1.60	18.6	352.5	168.0	47.7
	25— 60	7.3	0.93	15.4	281.2	126.2	44.9
	60— 85	7.3	0.88	13.8	250.0	89.5	35.8
	85—105	7.5	0.88	12.6	250.0	89.0	35.6
	105—125	6.7	0.78	9.0	218.7	65.0	29.7
Surface							
Jawalamukhi	0— 15	6.9	1.45	22.2	437.5	187.5	42.9
Bankhandi	0— 15	7.9	2.12	21.8	437.5	362.5	82.9
Sangaria	0— 15	7.1	0.72	12.6	250.0	56.2	22.5
Bihal Kudli	0— 15	6.4	1.04	18.5	312.0	74.5	23.9
Profile 7							
Hamirpur	0— 20	6.4	1.04	24.0	500.0	292.5	58.5
	20— 32	6.7	0.80	22.6	437.5	241.5	55.2
	32— 40	6.6	0.80	19.8	406.2	208.0	51.2
	40—62	6.5	0.80	17.5	375.0	176.0	46.9
	62—100	6.6	0.80	16.8	375.0	168.0	44.8
	100—120	6.7	0.41	13.6	352.7	118.0	33.5
Surface							
Sujanpur	0— 15	6.3	1.30	23.0	437.5	225.0	51.4
Jalari	0— 15	6.6	0.93	19.4	352.7	96.5	27.4
Sachal	0— 15	7.6	1.69	21.4	500.0	287.5	57.5
Bhota	0— 15	6.0	1.68	20.5	437.0	218.2	50.0
Dalhauzie	0— 15	6.3	2.80	29.2	687.0	44.0	15.7
Chaniani	0— 15	6.5	1.04	17.6	281.0	44.0	15.7
	Average	6.9	1.24	18.1	361.5	161.2	40.6

Table 4

Linear coefficient of correlation between organic P, total P and soil properties

	pH	Organic matter	Clay	Total P
Organic P	−0.42**	+0.61**	+0.83**	+0.92**
Total P	−0.28*	+0.80**	+0.88**	—

** Significant at 1% level.
* Significant at 5% level.

organic P respectively. The regression equations read as under:

$$Y_1 = 341.44 + 4.27\,x_1 + 1.54\,x_2 + 3.18\,x_3 \quad (R^2 = 0.99^{**};\ P = 0.01) \tag{i}$$

$$Y_2 = 52.80 + 119.38\,x_1 - 7.36\,x_2 + 1.82\,x_3 \quad (R^2 = 0.55^{**};\ P = 0.01) \tag{ii}$$

where Y_1 = total P, Y_2 = organic P, x_1 = organic matter, x_2 = pH and x_3 = clay content in both the equations.

The amount of total phosphorus found in the non-calcic brown, grey-brown podzolic and reddish chestnut soils falls into the range reported by other workers, such as WILLIAMS—SAUNDERS (1956), WALKER—ADAMS (1959) and JOHN—GARDNER (1971) for the soils of Scotland, New Zealand and Canada, respectively. The non-calcic brown and grey-brown podzolic soils appear to be much richer in total reserve of phosphorus than reddish chestnut soils. This is attributed to the fact that the non-calcic brown and grey-brown podzolic soils have developed on material of recent origin. Variations in parent material, climate and vegetation in these soils might be other factors responsible for the differences in their total P reserve. WILD (1958), while working on soils in Australia, observed that soils containing less than 0.017% (170 ppm) of total P showed a severe deficiency of P. If this criterion is applied to the soils under study, then all the soils are sufficiently supplied with total P reserves. Even under these situation, however, these soils are fairly deficient in available P (SHARMA—BHUMBLA 1975) and are highly responsive to applied phosphorus (MAHAJAN *et al.* 1974). This might be due to the higher stability and possibly the lower solubility of total P in these soils apart from their high phosphorus fixing capacities.

The content of organic P in these soils is in accordance with the amount reported by WILLIAMS—STEINBERGS (1958) and KAILA (1963b) for some Australian and Finnish soils. The higher amount of organic P in non-calcic brown and grey-brown podzolic soils in comparison to reddish chestnut soils might be due to the higher organic matter build-up in the former two groups of soils, besides low mineralization or organic P due to low temperature and weak microbial activity (THOMPSON—BLACK 1950). It has been reported that the proportion of organic P is low in areas with low rainfall and may increase to about 90% of the total P in the wettest area. This might be another reason to explain the higher content of organic P in non-calcic brown and grey-brown podzolic soils, where the average annual rainfall is 1000—1500 mm and more than 1500 mm, respectively, compared to reddish chestnut soils where it ranges between 750—1000 mm. FLOATE (1965) explained this behaviour in terms of an increasing capacity for plant growth with increasing precipitation, as a result of which organic matter build-up would be greater, leading to a higher accumulation of organic P.

The decrease in total and organic P with depth (Figs 3, 4) in the profiles of the three groups of soils is attributed to the enrichment of surface soils by upward translocation of phosphorus from the sub-soils through the agency of the roots, and the subsequent retention

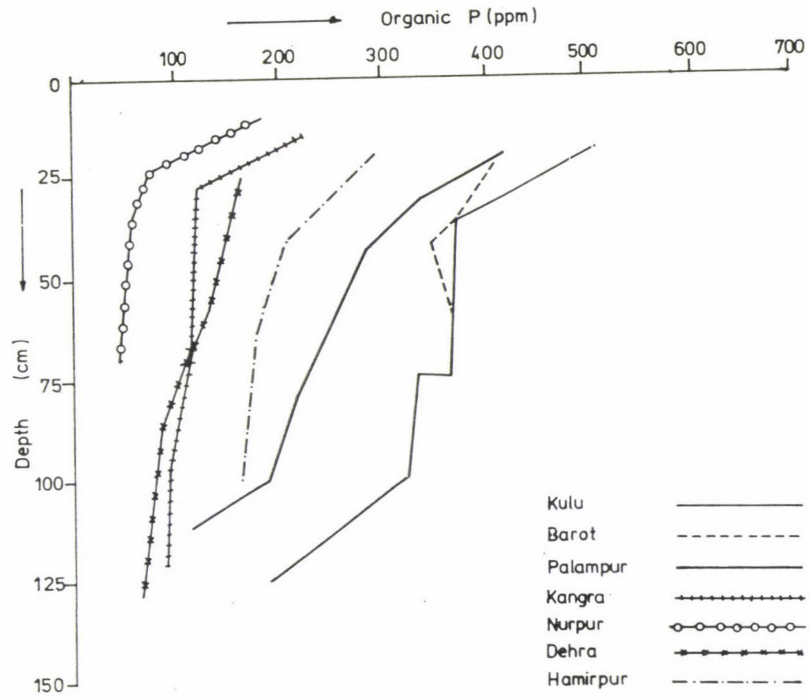

Fig. 3. Distribution of organic P in various profiles

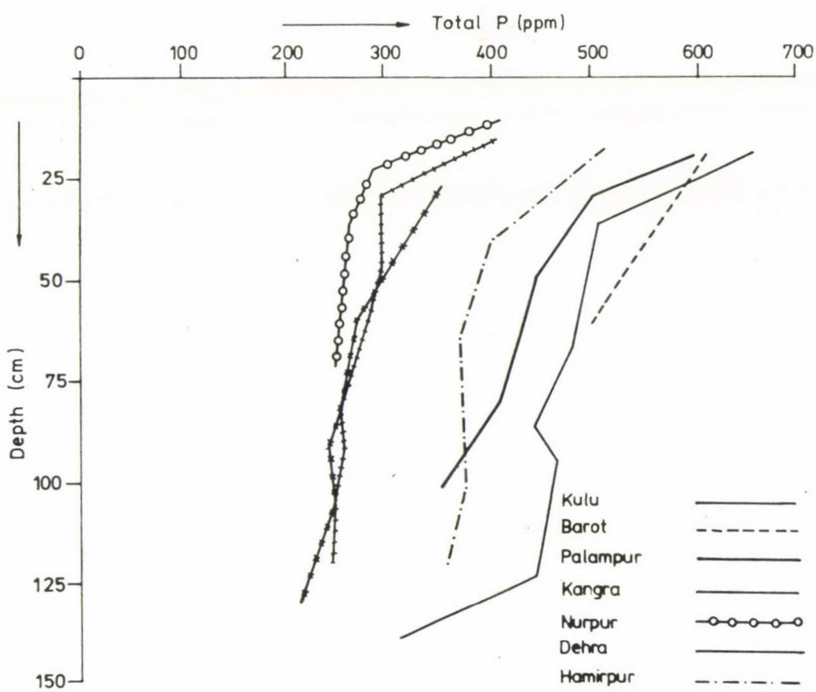

Fig. 4. Distribution of total P in various profiles

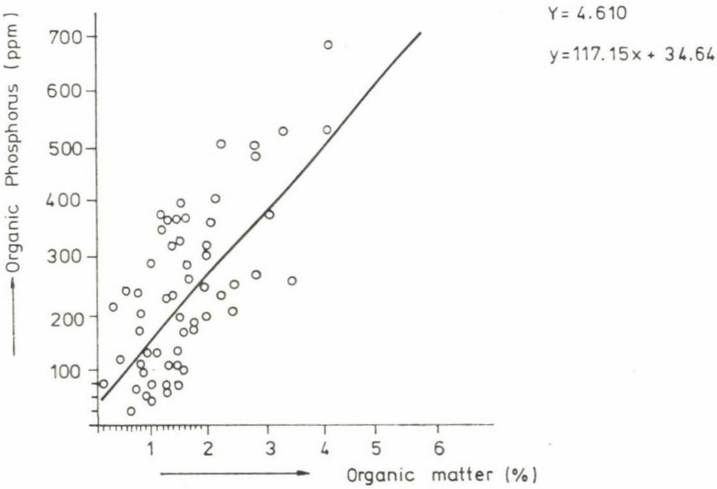

Fig. 5. Relationship between organic matter and organic P

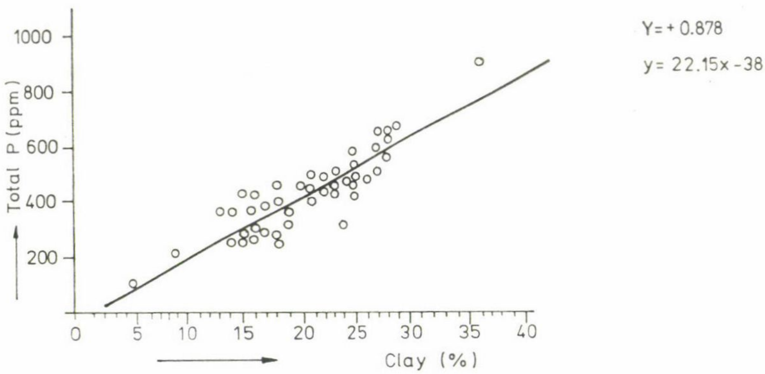

Fig. 6. Relationship between clay and total P

and accumulation of phosphorus in the surface layers against rapid downward movement caused by leaching. The decrease of organic P with depth is most likely due to its association with organic matter content, which also decreases with depth. Since these are agricultural soils, there is reason to believe that the soils under study might have been enriched by organic manures and chemical fertilizers so as to give rise to higher amounts of organic and total P in the surface layers. A similar pattern of distribution was observed by WILLIAMS—SAUNDERS (1956) and JOHN—GARDNER (1971). The relationship of organic and total P with pH, organic matter and clay were worked out through simple correlation coefficients (Table 4). The negative association of total and organic P with pH suggests that both these forms are more stable at low than at high pH levels in the soils under study. ENWEZOR (1967) also obtained similar results and concluded that the organic P content tended to decrease with a rise in pH. HALSTEAD *et al.* (1967) and KAILA (1965) explained it in terms of an increase in the mineralization of organic P with an increase in soil pH. The effect of soil pH on organic P mineralization may be accounted for by the theory that raising the pH reduces the sorption of organic P compounds by hydrous oxides of aluminium and iron and hence increases their solubility and susceptibility to mineralization. The highly significant positive relationship of organic and total P with organic matter (Table 4) indicates that organic P is a part of both the organic matter and the total P and that it varies with the organic matter and total P. Organic and total P (Fig. 6) showed a significant positive relationship with clay, which could be explained on the basis of the fact that clay particles have a fairly high capacity for retaining total and organic P by the anion adsorption phenomenon due to their higher anion holding powers. This observation agrees with the findings of WILLIAMS—SAUNDERS (1956) and HANLEY *et al.* (1965) for some Scottish and Irish soils.

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Prepared at the Department of Soil Science, H. P. University, Palampur, Indian Council of Agricultural Research, New Delhi

P. K. SHARMA, D. R. BHUMBLA, S. P. DEV

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GENOTYPE-ENVIRONMENT INTERACTION IN YIELD AND YIELD COMPONENTS OF SOYBEAN (GLYCINE MAX L. MERRILL.)

The presence of genotype-environment interaction creates difficulties in breeding programmes since it acts to confound comparisons among lines in most field situations. Accordingly, the importance of this has been appreciated for several decades, but the plant breeders were still unable to exploit it fully in breeding programmes, largely due to the problem of defining or measuring adaptability and the complexities of environments. Recent development in this field has removed many of these problems and methods have now been developed which could be used to provide reliable estimates of this interaction (YATES—COCHRAN 1938, MATHER—JONES 1958, JINKS—STEVENS 1959, FINLEY—WILKINSON 1963, BUCIO ALANIS 1966, BUCIO ALANIS—HILL 1966, EBERHART—RUSSELL 1966, PERKINS—JINKS 1968a, b, BREESE 1969, BUCIO ALANIS *et al.* 1969).

In any breeding programme, it is necessary to screen and identify phenotypically stable genotypes which could perform more or less uniformly under different environmental conditions. This is specially true for soybean whre seasonal fluctuations in the performance of different varieties are quite high because of their latitudinal specificity. Such a breeding effort requires information on the extent of genotype-environment interaction for yield and its components. In the present investigation, 21 varieties of soybean were evaluated to study the genotype-environment interaction and to find out the stability of these varieties in respect of yield and yield components.

Materials included 21 varieties of soybean (listed in Table 2) sown on seven different sowing dates during the year 1976—1977. The seven sowing dates were 1st of May, June, August, October, November and December 1976 and January 1977. The crops raised in July and September 1976 were lost due to bad weather conditions at the time of harvest and were discarded. The experiment had three replications per sowing with a single plot of 10 spaced plants for each variety. The distance between the plots and that between plants were 45 cm and 15 cm respectively. The characters studies were yield/plant and six other yield components, namely, fruit number/plant, fruit weight/plant, seed number/fruit, seed weight/10 fruit, seed number/plant and 100-seed weight. The basic data used in the analysis are the means of the 10 plants of each variety within a replication.

Analysis of variance is shown in Table 1. The difference between genotypes and between environments and the genotype-environment interaction along with both its components (linear and non-linear) were highly significant for all the characters. The ratio of linear to non-linear component of genotype-environment interaction was quite high for fruit number per plant, fruit weight/plant, seed number/ plant and yield/plant. Since the genotypes interacted with the environments significantly, no immediate generalization regarding the relative performance of these varieties over a range of environments was made, but the analysis argues that valid comparisons can only be made in each environment separately.

The mean performance of the genotypes (expressed as a percentage over the grand mean) and the two parameters of genotype-environment interaction (b and $\bar{S}_d^2$) are shown

Table 1

Results of analysis of variance

Item	d. f.	Characters						
		Fruit number/plant	Fruit weight/plant	Seed number/fruit	Seed weight/ 10 fruit	Seed number/plant	100-seed weight	Yield/plant
Genotype (G)	20	17,738***	1,658***	0.612***	3.907***	52,344***	121.49***	667.9***
Sowing date (E)	6	60,009***	5,559***	1.543***	3.280***	150,857***	73.05***	2446.9***
G × E	120	2,594***	307***	0.172***	0.996***	8,029***	13.10***	153.0***
Regression	20	9,867***	970***	0.190***	1.107***	25,394***	13.13***	457.1***
Deviation	100	1,139***	174***	0.169***	0.974***	4,556***	13.09***	92.2***
Reps in E	14	185	20	0.032*	0.120	230	0.71	7.03
Error	280	282	36	0.019	0.103	1,198	1.81	18.1
Ratio of linear to non-linear component		8.66	5.56	1.13	1.14	5.57	1.00	4.96

*, *** Significant at 5% and 0.1% level respectively.

in Tables 2, 3 and 4. The mean squares measuring the scatter of the points about individual regression lines were heterogeneous (X^2 in Bartlett's test was significant at the 1% level) indicating that the extent of deviation from regression was specific to and characteristic of particular populations. With a very few exceptions, the genotypes which gave a higher mean performance for the characters studied were also found to be highly responsive to the variation in the environmental conditions as represented by their high regression coefficients (b). This was specially true for yield/plant and three other yield components, fruit number/plant, fruit weight/plant and seed number/plant. For these characters the genotypes SJ-2, EC-11780, Horosy, Improved Pelican and SJ-1 performed better over the grand mean in that order. Among them EC-11780 was the most sensitive and SJ-1 showed unit response to change in environmental conditions. Very high $\bar{S}_d^2$ values in these five genotypes (except Improved Pelican) also indicated their instability in respect of these four characters. However, for fruit number/plant EC-11780 revealed considerable stability. Forrest, TK-5 and Adelplia showed the least deviation around their respective regression slopes (low $\bar{S}_d^2$) indicating high stability in respect of fruit number/plant, fruit weight/plant and seed number/plant, respectively. Adelplia was also the most stable genotype ($\bar{S}_d^2 = 0.46$) for yield/plant. All of these three varieties, however, had a low mean performance and low response to environments for these characters. Lee-74, TK-5 and Biloxi were also considerably stable for yield/plant. Among them Biloxi was responsive and a high yielder too. This variety gave an average response (b is non-significant from unity) to environment in respect of fruit number and seed number/plant. For these two characters Kao Asiang and Multour were the least responsive varieties. They also gave low b values for fruit weight/plant and yield/plant. TK-5 and Forrest were

Table 2

Mean performance of the genotypes, expressed as a percentage over the grand mean for the seven characters

Varieties	Fruit number/ plant	Fruit weight/ plant	Seed number/ fruit	Seed weight/ 10 fruit	Seed number/ plant	100-seed weight	Yield/ plant
1. Bragg	64.7	74.3	109.4	113.3	67.8	103.8	72.3
2. Lee-74	53.6	63.7	106.7	104.4	60.3	98.9	63.1
3. Hardee	104.4	106.1	99.7	112.5	105.5	107.2	113.8
4. TK-5	87.5	95.5	92.2	97.0	81.8	103.8	90.5
5. Improved Pelican	186.3	159.2	91.2	79.7	167.9	86.4	151.2
6. Kao Asiang	59.1	63.7	90.6	98.2	56.0	101.7	63.1
7. SRF-425	60.3	53.1	105.1	95.2	63.5	88.4	55.6
8. Williams	74.9	84.9	108.3	103.0	84.0	104.5	86.4
9. Semees	69.9	74.3	97.6	107.0	71.0	112.1	74.8
10. Multour	39.2	42.4	101.3	93.0	37.7	95.4	38.2
11. Adelplia	53.0	69.0	119.6	131.4	65.7	118.4	78.9
12. CNS	93.6	90.2	99.7	90.8	94.7	87.7	87.2
13. EC-11780	205.8	180.4	98.7	76.4	208.0	77.3	185.2
14. Forrest	73.7	74.3	113.1	101.1	80.7	90.5	72.3
15. Biloxi	110.9	169.8	80.4	125.8	93.6	153.2	159.5
16. Wells	34.9	42.4	111.0	125.5	39.8	111.4	47.3
17. Punjab	97.4	84.9	90.6	98.5	91.5	108.6	83.1
18. Horosy	198.2	175.1	94.9	75.6	199.1	78.0	181.9
19. UPSM-19	75.8	79.6	96.5	103.3	76.4	102.4	83.9
20. SJ-1	147.6	127.3	94.4	80.1	141.0	85.0	121.3
21. SJ-2	209.1	191.0	99.2	86.3	213.1	85.7	191.0

the least responsive varieties for yield/plant. The genotypes EC-11780, Improved Pelican and TK-5 gave the lowest $\bar{S}_d^2$ values for seed number/fruit, seed weight/10 fruit and 100-seed weight respectively, indicating their high stability for these characters. Wells was the least responsive in respect of seed number/fruit and 100-seed weight but for seed weight/10 fruit it gave a very high negative response ($b = -3.21$). The performance of this variety was above average for all of these three characters. The 100-seed weight of Bragg and Adelplia was higher than the grand mean, while the regression coefficient did not differ significantly from unity and the $\bar{S}_d^2$ value was low, indicating their unit response to environmental change and a high stability for this character.

The response of genotype to environmental variation differs from character to character. The degree of association between such responses measured by the correlation coefficients between the b values of various characters is given in Table 5. It is evident that the fluctuation in yield with changing environments was highly and positively associated with a similar response in fruit number/plant, fruit weight/plant and seed number/plant. Moreover, the mean performance of the genotypes was highly and positively correlated with their regression

Table 3

Regression coefficients (b) and their standard errors (S_b) for individual genotypes over the environmental mean

Var*	Fruit number/plant	Fruit weight/plant	Seed number/fruit	Seed weight/10 fruit	Seed number/plant	100-seed weight	Yield/plant
	b ± S_b	b ± S_b	b ± S_b	b ± S_b	b ± S_b	b ± S_b	b ± S_b
1.	0.68 ± 0.12	0.61 ± 0.14	1.21 ± 0.39	2.40 ± 0.59	0.70 ± 0.15	0.89 ± 0.59	0.59 ± 0.15
2.	0.46 ± 0.19	0.59 ± 0.29	1.34 ± 0.58	2.30 ± 0.96	0.55 ± 0.26	0.75 ± 0.57	0.58 ± 0.27
3.	1.33 ± 0.09	1.27 ± 0.13	1.14 ± 0.39	2.32 ± 1.03	1.34 ± 0.15	3.08 ± 1.01	1.36 ± 0.15
4.	0.26 ± 0.17	0.16 ± 0.28	1.05 ± 0.29	0.31 ± 1.11	0.15 ± 0.24	−0.39 ± 0.43	0.08 ± 0.29
5.	2.48 ± 0.22	2.38 ± 0.28	2.09 ± 0.39	0.64 ± 0.58	2.12 ± 0.35	0.97 ± 0.85	2.23 ± 0.24
6.	−0.02 ± 0.11	0.13 ± 0.11	0.90 ± 0.63	0.07 ± 1.07	−0.06 ± 0.14	0.50 ± 0.79	−0.13 ± 0.13
7.	0.59 ± 0.05	0.50 ± 0.62	1.63 ± 0.38	1.27 ± 0.89	0.53 ± 0.08	1.96 ± 0.62	0.42 ± 0.08
8.	0.61 ± 0.12	0.50 ± 0.13	0.31 ± 0.59	2.03 ± 0.52	0.68 ± 0.21	1.71 ± 1.05	0.48 ± 0.04
9.	0.81 ± 0.09	0.66 ± 0.11	0.23 ± 0.49	2.70 ± 0.79	0.85 ± 0.13	2.82 ± 0.82	0.64 ± 0.12
10.	0.03 ± 0.10	0.02 ± 0.11	2.53 ± 1.39	2.25 ± 1.09	−0.09 ± 0.10	0.75 ± 0.61	−0.09 ± 0.10
11.	0.19 ± 0.17	0.22 ± 0.24	1.43 ± 1.01	3.00 ± 0.83	0.28 ± 0.26	0.99 ± 0.62	0.24 ± 0.28
12.	1.30 ± 0.11	1.19 ± 0.15	0.42 ± 0.28	1.11 ± 0.23	1.35 ± 0.17	1.33 ± 0.26	1.22 ± 0.16
13.	2.94 ± 0.24	3.12 ± 0.36	0.42 ± 0.34	3.02 ± 0.98	3.19 ± 0.46	1.32 ± 1.11	3.36 ± 0.46
14.	0.27 ± 0.22	0.10 ± 0.19	1.96 ± 1.35	1.76 ± 1.24	0.32 ± 0.23	1.07 ± 1.40	0.08 ± 0.15
15.	0.95 ± 0.13	1.89 ± 0.21	0.28 ± 0.39	−0.78 ± 1.32	0.92 ± 0.12	−0.32 ± 1.22	1.84 ± 0.27
16.	0.10 ± 0.13	0.10 ± 0.18	−0.07 ± 1.21	−3.21 ± 1.42	0.14 ± 0.19	0.21 ± 0.73	0.11 ± 0.20
17.	1.76 ± 0.16	1.44 ± 0.14	0.26 ± 0.21	2.04 ± 0.69	1.77 ± 0.24	1.69 ± 1.12	1.30 ± 0.10
18.	2.29 ± 0.27	2.71 ± 0.49	0.72 ± 0.49	−0.84 ± 0.61	2.58 ± 0.39	−0.43 ± 0.63	2.93 ± 0.53
19.	0.72 ± 0.05	0.86 ± 0.11	0.23 ± 0.51	−0.08 ± 0.68	0.79 ± 0.09	0.40 ± 0.81	0.98 ± 0.10
20.	1.41 ± 0.39	1.21 ± 0.46	0.64 ± 0.72	0.34 ± 0.68	1.24 ± 0.48	0.94 ± 0.36	0.98 ± 0.43
21.	1.72 ± 0.27	1.61 ± 0.37	1.52 ± 0.28	0.92 ± 0.56	1.59 ± 0.37	0.36 ± 0.23	1.64 ± 0.43

* Varieties numbered as in Table 2.

Table 4

Deviation from regression ($\bar{S}_d^2$) for different genotypes and characters

Var*	Fruit number/plant	Fruit weight/plant	Seed number/ruit	Seed weight/ 10 fruit	Seed number/plant	100-seed weight	Yield/ plant
1.	−199.26	−26.23	0.004	0.004	−898.0	0.77	−13.11
2.	−68.01	7.28	0.032	0.185	−241.1	0.52	−1.48
3.	−233.59	−28.34	0.004	0.229	−899.7	5.48	−13.71
4.	−110.20	3.63	−0.006	0.280	−362.4	−0.49	2.23
5.	15.82	5.76	0.111	0.001	604.9	3.45	−6.31
6.	−207.31	−29.62	0.040	0.258	911.9	2.71	−14.28
7.	−266.06	−34.70	0.003	−0.057	−1110.9	0.97	−16.78
8.	−197.38	−26.90	0.034	−0.017	−576.8	6.11	−9.14
9.	−234.30	−29.68	0.018	0.095	−977.3	3.00	−15.09
10.	−219.87	−29.81	0.272	0.271	−1053.1	0.86	−5.30
11.	−121.69	−6.16	0.135	0.110	228.3	0.95	0.46
12.	−219.29	−25.08	−0.007	−0.087	−770.7	−1.33	−12.89
13.	55.24	30.59	−0.002	0.262	1827.1	7.02	26.41
14.	3.00	−17.26	0.024	0.380	−403.3	12.36	−12.95
15.	−186.57	−13.32	−0.005	0.441	−987.7	8.88	−2.46
16.	−180.92	−18.94	0.202	0.528	−641.8	2.07	−8.69
17.	−139.60	−25.83	−0.012	0.043	−404.9	7.20	−16.20
18.	145.73	86.28	0.016	0.012	1078.3	1.06	47.41
19.	−264.05	−29.89	0.019	0.054	−1078.0	2.92	−15.62
20.	598.17	73.27	0.058	0.042	2175.3	−0.89	25.62
21.	152.16	36.08	0.007	−0.005	776.4	−1.42	25.45

* Varieties numbered as in Table 2.

coefficients in fruit number/plant, fruit weight/plant, seed number/plant and yield/plant, indicating that the genotypes with higher means were more susceptible to environmental changes for these characters.

The comparison of a set of genotypes over a number of environments often shows that the genotypic effects are not fixed and accordingly the genotype-environment interaction has long been recognized as an important source of variation (IMMER *et al.* 1934, YATES—COCHRAN 1938, MATHER 1949). Recent studies, in general, have revealed that the genotype-environment interaction component is often a linear function of environmental means when the environment is measured by its effect on the characters under study (FINLEY—WILKINSON 1963, EBERHART—RUSSELL 1966, PERKINS—JINKS 1968a, BREESE 1969, PARODA—HAYES 1971, FRIPP—CATEN 1971) although there is frequently a significant non-linear effect. This was true in the present investigation also. The ratio of linear versus non-linear component was high for fruit number/plant, fruit weight/plant, seed number/plant and yield/plant. Therefore, the difference between the genotypes could be explained by the difference between the slopes of

Table 5

Correlation coefficient between the b values, and between the mean and b values of different characters

	Fruit number/plant	Fruit weight/plant	Seed number/fruit	Seed weight/10 fruit	Seed number/plant	100-seed weight	Between mean and b
Fruit number/plant							0.90***
Fruit weight/plant	0.96***						0.88***
Seed number/fruit	−0.14	−0.19					0.26
Seed weight/10 fruit	0.09	−0.02	0.35				−0.06
Seed number/plant	0.99***	0.96***	−0.21	0.12			0.87***
100-seed weight	0.09	−0.06	−0.002	0.63**	0.09		−0.07
Yield/plant	0.95***	0.99***	−0.21	−0.02	0.96***	−0.07	0.88***

, * Significant at 1% and 0.1% level respectively.

their linear regression for these characters. Comparatively higher values of the non-linear component of genotype-environment interaction for seed number/fruit, seed weight/10 fruit and 100-seed weight may be due to the presence of substantial response differences between the genotypes for more than one environmental factor (PERKINS—JINKS 1968b, HARDWICK—WOOD 1972, PARODA—MEHROTRA 1976).

Successful evaluation of stable genotypes is possible through genotype-environment interaction studies. Originally FINLEY—WILKINSON (1963) considered the linear regression slopes (b) as a measure of stability, but later EBERHART—RUSSELL (1966) emphasized the need to consider both regression slopes (b) and deviation from regression ($\bar{S}_d^2$) in judging the stability of a genotype. While the latter concept of stability merits practical consideration, the former one retains the condition of relatively little or no response of a genotype to the changing environmental conditions. Accordingly, BREESE (1969), SAMUEL *et al.* (1970) and PARODA—HAYES (1971) advocated that the linear regression could simply be regarded as a measure of the response of a particular genotype, which in fact is dependent largely on the number of genotypes included in a particular study, taking the deviation around the regression line as a measure of stability, genotypes with the lowest deviation being the most stable and vice versa. Hence the ideal variety would be one with high mean performance, unit regression slope ($b = 1.00$) and the deviation from regression as small as possible ($S_{d^2} = 0.0$). But most varieties failed to combine these three criteria. In general, genotypes with a high mean performance had a regression coefficient of more than 1.00 and a larger deviation from regression than the genotypes with low performance. A similar observation was also reported by SMITH *et al.* (1967) in this crop.

The genotypes Improved Pelican and Biloxi which have higher mean yields and regression coefficients together with quite low $\bar{S}_d^2$ values will be suitable for favourable environments. Although EC-11780 and Horosy had high deviations around their regression lines they also had very high b values which suggests that they should also be included in suitable environments. These varieties are very sensitive to environmental changes and hence, as the environment improves, their yield increases at a rate well above the average of the group. Under the most favourable conditions they will be able to express themselves as very high yielding varieties, suggesting their exploitation in favourable environments. On the other hand, TK-5, Adelplia and Forrest, which have comparatively low b and S_{d^2} values combined with a mean yield not much less than the grand mean, are specially adapted to low yielding environments. These varieties are so insensitive, in fact, that they are unable to exploit the high yielding environments. Multour and Wells had low b and S_{d^2} values but their very low mean yield indicates that they were consistently low yielders in all the environments.

Positive and significant correlations between means and regression coefficients for fruit number/plant, fruit weight/plant, seed number/plant and yield/plant were in agreement with similar findings by VERMA *et al.* (1972) in this crop. This is of particular interest and relevance to the breeder, specially when his aim is to breed varieties which are responsive to high inputs. Moreover, high correlations between the regression coefficients of these four characters with each other indicate that the selection of varieties responsive for all of them will be easy.

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Prepared at the Department of Botany, University of Chittagong, Chittagong

M. SALEHUZZAMAN, O. I. JOARDER

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TRITICALE, WHEAT AND RYE RESPONSES TO LIMING TOPSOILS AND SUBSOILS OF TWO SOIL TYPES

The lime requirement for triticale (*Triticosecale*, Wittmack) in the soils of the southeastern U.S. have not been studied extensively. However, field studies conducted in Alabama have shown that lime and fertilizer requirements for California-bred triticales generally vary from one soil to another (unpublished data). Similar variations in lime responses by these triticales were reported previously (MUGWIRA *et al.* 1976). These workers studied triticale responses to liming five Alabama topsoils (samples collected from 0—15 cm depth) in pot studies. They found that lime application at rates based on wheat recommendation increased the growth of triticale 6TA 131 and Trailblazer on two soils and that of 6TA 385 on three soils. The degree of response to lime appeared to be associated with reductions of high exchangeable Al and Mn.

The soils of Alabama are representatives of the major soils of the southeast region of the U.S. (PEARSON—ADAMS 1967). These soils are generally highly weathered and eroded and often contain more exchangeable Al and Mn in the subsoils than topsoils. Aluminium toxicity to plants is a growth-limiting factor on crops grown on some soils of the southeastern U.S. (ADAMS—LUND 1966, ADAMS—PEARSON 1970, FOY *et al.* 1965a, FOY *et al.* 1965b, MOSCHLER *et al.* 1970). Manganese toxicity is also considered a major problem in some acid soils of this area (PEARSON—ADAMS 1967). The major differences in lime requirements for Alabama soils have been pointed out by Adams (ADAMS 1956, 1968). He stated that Ca deficiency is not considered a major problem in the southern U.S. region but Mg deficiency can be caused by using limestones containing small amounts of Mg or using high rates of K on soils with low CEC. Previous research indicates that for many crops consideration should be given to maintaining critical Ca, Mg and K ratios which are affected by liming (GRUNES *et al.* 1970, HOWARD-ADAMS 1965, TODD 1966).

Many of the problems associated with acid soil toxicity are more pronounced in subsoils than in topsoils. Triticales being tested in Alabama generally tend to have longer and less branched roots than wheats. Many of these triticales have been developed in regions with soils which are less acid than those of this area. It is not clear to what extent high subsoil acidity common in Alabama soils limits the performances of these triticales in different soils. The object of this study was to determine the relative effects of liming topsoils and subsoils on the growth and mineral composition of triticale, wheat (*Triticum aestivum* L.) and rye (*Secale cereale* L.).

Hartsells sandy loam and Dickson silt loam, two major soil types of north Alabama, were used. Soil samples were collected from the 0—15 cm (topsoil) and 15—30 cm (subsoil) from each site. Lime and fertilizer were applied based on recommendations for the topsoils by the Auburn Soil Testing Laboratory. The N, P_2O_5 and K_2O applications were 110, 132 and 66 kg/ha, respectively.

Soils were screened and bulk lots were treated with dolomitic limestone at rates equivalent to 0.0, 0.5 and 1.0 units of lime recommendation as described previously (MUGWIRA *et al.* 1976). Hexaploid triticales 6TA 131 and 6TA 385, Arthur wheat and Abruzzi rye were planted in all treatments and replicated three times for topsoils and four times for subsoils. The plants were grown in pots containing 5 kg soil for 8 weeks in a greenhouse with an average daily temperature of 25 °C and night temperature of 17 °C. Artificial lighting was used as needed to extend the light period to 16 hours daily. The first tests were done on treated topsoils and later subsoils were used.

Shoots and roots were harvested separately, dried at 70 °C, ground and processed for analysis. Calcium, Mg, and Mn were determined by atomic absorption, K by flame photometry and Al by the Cyanine R method (JONES—THURMAN 1957). Exchangeable Ca, Mg, K, and Mn in soils were determined in 1 N NH_4OAc extract and Al was extracted with 1 N KCl.

Increasing the lime rate generally resulted in proportional significant increases in the pH and NH_4OAc extractable Ca and Mg of topsoils and subsoils of Hartsells sandy loam and Dickson silt loam (Table 1). However, exchangeable Ca was not significantly increased by the

Table 1

Effects of lime applications on pH and exchangeable cations in topsoils and subsoils of Hartsells and Dickson soils

Soil	Lime applied,* mt/ha	pH	Exchangeable cations				
			Ca	Mg	K	Al	Mn
			meq/100 g				
			Topsoils				
Hartsells sl	0.0	4.55	0.77	0.29	0.19	1.25	0.023
Hartsells sl	3.3	5.15	1.41	1.19	0.15	0.41	0.008
Hartsells sl	6.6	5.87	2.21	2.31	0.12	0.03	0.006
Dickson sil	0.0	4.29	1.42	0.26	0.10	0.83	0.057
Dickson sil	3.9	4.93	2.46	1.39	0.10	0.42	0.027
Dickson sil	7.8	5.72	3.04	1.90	0.11	0.04	0.013
LSD (0.05)		0.44	1.25	0.39	0.04	0.27	0.032
			Subsoils				
Hartsells sl	0.0	4.16	0.28	0.07	0.38	2.33	0.008
Hartsells sl	3.3	4.56	0.59	0.44	0.29	0.45	0.009
Hartsells sl	6.6	5.66	0.94	0.68	0.35	0.09	0.009
Dickson sil	0.0	4.09	0.85	0.14	0.28	0.74	0.062
Dickson sil	3.9	5.04	1.14	0.47	0.22	0.07	0.013
Dickson sil	7.8	5.69	1.45	0.70	0.30	0.17	0.011
LSD (0.05)		0.34	0.33	0.21	0.03	0.62	0.017

* Lime recommendations were 6.6 and 7.8 mt/ha, respectively, for Hartsells and Dickson soils.

addition of half the recommended lime rate when compared with the values obtained with the unlimed topsoils and subsoils. Liming reduced exchangeable K in Hartsells topsoil but no consistent trends were obtained with the other soils. Increasing the dolomite application rate significantly reduced exchangeable Al in soils except for the lack of differences between

0.5 and 1.0 units of lime recommendation in Dickson subsoils. Exchangeable Al in unlimed Hartsells subsoil was significantly higher than in Dickson topsoil and subsoil. There was greater reduction of exchangeable Al caused by liming Hartsells soils than in Dickson soils. Unlimed Dickson soils contained more exchangeable Mn than unlimed Hartsells soils but these differences were not observed in limed soils. Only the recommended lime rate significantly reduced exchangeable Mn in Dickson topsoil while half that rate reduced exchangeable Mn in subsoils. There were no other effects due to liming rates.

From the standpoint of neutralizing acidity and supplying Ca and Mg the recommended lime rate was more effective than 0.5 units of lime recommendation when compared to unlimed soils. However, half the lime recommended was as effective as the lime recommendation in terms of reducing exchangeable K in Hartsells topsoils, Al in Dickson subsoils and Mn except in Dickson topsoil.

The dry matter and mineral composition of triticales 6TA 131 and 6TA 385 were similarly affected by liming in all the soils used. The results of triticale 6TA 131 are, therefore, omitted from the following discussion for brevity while those of triticale 6TA 385 are used

Table 2

Effects of liming topsoils and subsoils of Hartsells and Dickson soils on the growth of triticale, wheat and rye

Soil	Lime applied,* mt/ha	Shoot			Root		
		Triticale	Wheat	Rye	Triticale	Wheat	Rye
		g/pot			g/pot		
		Topsoils					
Hartsells sl	0.0	3.00	1.44	4.66	0.40	0.24	0.64
Hartsells sl	3.3	6.44	5.20	6.54	0.86	1.02	1.14
Hartsells sl	6.6	6.02	5.76	5.80	0.60	0.90	0.98
Dickson sil	0.0	4.14	5.48	5.34	0.34	0.40	0.72
Dickson sil	3.9	5.48	5.44	6.20	0.52	0.54	0.48
Dickson sil	7.8	5.34	5.42	6.10	0.66	0.42	0.42
LSD (0.05)			1.30			0.40	
		Subsoils					
Hartsells sl	0.0	1.18	0.86	2.27	0.35	0.16	0.45
Hartsells sl	3.3	4.69	3.03	5.75	1.14	0.54	1.27
Hartsells sl	6.6	7.74	3.99	6.95	1.95	0.68	1.08
Dickson sil	0.0	3.89	3.19	3.44	0.94	0.74	0.70
Dickson sil	3.9	5.15	3.14	4.92	1.25	1.01	0.81
Dickson sil	7.8	4.57	3.48	4.11	1.18	0.73	0.46
LSD (0.05)			1.52			0.60	

* Lime recommendations were 6.6 and 7.8 mt/ha, respectively, for Hartsells and Dickson soils.

for comparison with wheat and rye. Dry matter yields indicate that applying dolomite at half the recommender rates significantly increased the growth of all three species in Hartsells soils (Table 2). Liming Dickson soils at half the recommended rate only increased the growth of triticale in topsoil. Increasing the liming rates from 0.5 to 1.0 units of lime recommendations only increased triticale shoot and root dry matter in Hartsells subsoils. These data indicate triticale 6TA 385 was more susceptible to the high subsoil acidity of Hartsells soil and Dickson topsoil than Arthur wheat and Abruzzi rye. Since triticales 6TA 131 and 6TA 385 showed similar lime responses it may be reasonably assumed that California-bred triticales are more susceptible to Hartsells subsoil acidity than Arthur wheat and Abruzzi rye.

While the lime responses noted above were statistically significant it was felt that examining relative responses (limed/unlimed) could yield additional information for comparing results from topsoils and subsoils. Table 3 shows the relative growth responses to lime. These data indicate that the growth of triticale and rye was stimulated more by liming the subsoil than the topsoil of Hartsells soil. Wheat grown in Hartsells soil and triticale, wheat and rye grown in Dickson soil showed similar relative growth responses to liming topsoils and subsoils. The relative lime responses were wheat > triticale > rye shoot and wheat > triticale and rye roots in Hartsells topsoils while in Dickson topsoils triticale and rye > wheat tops and

Table 3

Relative growth responses of triticale, wheat and rye to liming Hartsells and Dickson topsoils and subsoils

Soil	Lime applied,* mt/ha	Shoot			Root		
		Triticale	Wheat	Rye	Triticale	Wheat	Rye
		(Lime/No Lime) %					
		Topsoils					
Hartsells sl	0.0	100	100	100	100	100	100
Hartsells sl	3.3	215	361	140	215	425	178
Hartsells sl	6.6	201	400	125	150	375	153
Dickson sil	0.0	100	100	100	100	100	100
Dickson sil	3.9	132	99	116	153	135	67
Dickson sil	7.8	129	99	114	194	105	58
		Subsoils					
Hartsells sl	0.0	100	100	100	100	100	100
Hartsells sl	3.3	397	352	253	323	338	282
Hartsells sl	6.6	656	464	306	557	425	240
Dickson sil	0.0	100	100	100	100	100	100
Dickson sil	3.9	132	98	143	133	136	116
Dickson sil	7.8	117	109	119	126	99	66

* Lime recommendations with 6.6 and 7.8 mt/ha, respectively, for Hartsells and Dickson soils.

wheat × rye roots. In the subsoils the relative lime responses were triticale × wheat × rye in Hartsells and triticale and rye × wheat tops in Dickson, while root responses in Dickson subsoil were triticale and wheat × rye. These data also indicate that liming Dickson soils tended to reduce the root growth of rye.

Increases in plant dry weights caused by liming Hartsells and Dickson soils in this study were much higher than those reported previously (MUGWIRA *et al.* 1976). The soils used in the present study had lower initial pH than those used earlier. For example, Hartsells used earlier had a pH of 4.7—4.8 and Dickson had a pH of 4.7 compared with 4.55 and 4.29, respectively, for the present study. However, from the data in Tables 1, 2, and 3 it appears that differences in soil pH values per se did not account for the differences in relative lime responses obtained. For example, liming Hartsells subsoil from pH 4.16 to 5.66 (Table 1) increased plant growth by 656, 464 and 306% (Table 3), respectively, for triticale, wheat and rye; the corresponding responses from increasing Dickson subsoil pH from 4.09 to 5.69 were only 117, 109 and 119%, respectively. These data indicate that there were some other soil acidity factors, besides pH, affecting the growth of triticale, wheat and rye in Hartsells and Dickson soil. The dry matter from topsoils and subsoils, however, also suggests that when soil pH was 4.93 to 5.04 liming did not increase plant growth (Tables 1 and 2).

Liming did not significantly affect the Ca concentration in the tops of triticale, wheat and rye grown in Hartsells and Dickson topsoils (Table 4). However, liming subsoils significantly increased the Ca levels in the shoots of triticale and rye in Hartsells and wheat and rye in Dickson. Wheat and rye grown in limed Dickson topsoil and all the three plant species cropped to Dickson subsoil generally contained more Ca than when grown in Hartsells topsoil and subsoil. Half the lime recommendation significantly increased the Mg concentration of plant tops in topsoils and subsoils. Except for the lowering of the Mg level in triticale and increasing the Mg content in wheat grown in Hartsells subsoil and triticale in Dickson subsoil, there were no effects on Mg in shoots obtained by increasing lime rates from 0.5 to 1.0 units of lime recommendations. Rye generally contained more Mg than triticale.

Potassium concentration in plant tops was generally decreased by liming topsoils (Table 4). These reductions in plant K levels were obtained at the recommended lime rate in triticale planted in Hartsells topsoil and half the recommended rate with the other crops in topsoils. Crops grown in Hartsells subsoil generally had higher K levels in tops than those grown in Dickson subsoil. Liming subsoils only significantly reduced K concentration in triticale shoots in Dickson soil. Triticale and rye grown in unlimed soils generally had a higher K concentration than wheat. However, the differences in K concentrations in the three crops varied with lime rate and soil.

Aluminium concentration in wheat and rye shoot in Hartsells topsoils was significantyl reduced by dolomite at half the lime recommendation (Table 5). Only the recommended lime rate significantly reduced Al in plant tops of triticale. No significant differences in Al concentration were caused by increasing the lime rate applied to Hartsells topsoil from 0.5 to 1.0 units of lime recommendation and liming Dickson topsoil. The recommended lime rate reduced Al concentration in the plant tops of wheat and rye in Hartsells subsoil but no similar reductions in Al concentration in shoots were obtained in limed Dickson subsoil. Plants grown in subsoils of each soil accumulated more shoot Al than in their respective topsoils. Reductions in Al concentration caused by liming were generally associated with improved plant growth in Hartsells soils but not in Dickson soils.

Application of half the recommended lime rate reduced Mn concentration in plants except for triticale in Dickson topsoil and triticale, wheat and rye in Hartsells subsoil which were not affected (Table 5). However, the recommended lime rate significantly reduced Mn levels in shoots on all soils when compared with the unlimed soils. Plants grown in Dickson subsoil contained higher Mn levels in their tops than those grown in Hartsells subsoil.

Table 4

Calcium, Mg and K concentrations in triticale, wheat and rye plant tops as affected by liming Hartsells and Dickson soils

Soil	Lime applied,* mt/ha	Ca			Mg			K		
		Triticale	Wheat	Rye	Triticale	Wheat	Rye	Triticale	Wheat	Rye
		%								
		Topsoils								
Hartsells sl	0.0	0.26	0.28	0.28	0.18	0.30	0.32	6.25	5.46	5.96
Hartsells sl	3.3	0.36	0.30	0.36	0.68	0.72	0.74	5.96	4.96	3.84
Hartsells sl	6.6	0.34	0.40	0.38	0.78	0.84	0.80	5.50	5.41	5.30
Dickson sil	0.0	0.36	0.44	0.42	0.34	0.36	0.36	5.04	4.30	5.67
Dickson sil	3.9	0.46	0.50	0.52	0.62	0.90	0.96	4.21	3.67	4.46
Dickson sil	7.8	0.44	0.54	0.56	0.76	0.90	0.90	4.71	4.62	4.08
LSD (0.05)			0.16			0.14			0.42	
		Subsoils								
Hartsells sl	0.0	0.10	0.10	0.12	0.08	0.12	0.12	4.22	3.28	4.57
Hartsells sl	3.3	0.16	0.14	0.20	0.28	0.24	0.46	4.60	3.82	4.82
Hartsells sl	6.6	0.20	0.14	0.20	0.22	0.32	0.50	3.41	3.67	5.10
Dickson sil	0.0	0.28	0.18	0.26	0.18	0.16	0.26	3.13	2.75	3.66
Dickson sil	3.9	0.32	0.30	0.24	0.52	0.58	0.50	1.88	2.71	3.41
Dickson sil	7.8	0.32	0.22	0.32	0.50	0.58	0.82	1.61	2.27	3.10
LSD (0.05)			0.06			0.06			1.00	

* Lime recommendations were 6.6 and 7.8 mt/ha, respectively, for Hartsells and Dickson soils.

Liming Hartsells and Dickson soils with half the dolomite recommended was generally as effective as the lime recommendation in reducing Al and Mn concentrations in plant tops. However, the recommended lime rate was needed to lower significantly the Al in triticale tops in Hartsells topsoil and in wheat and rye grown in Dickson subsoils. Similarly, only the lime recommendation significantly reduced Mn levels in wheat and rye in Hartsells subsoil.

Improved plant growth in limed soils was associated with several trends in the mineral composition of plant tops. These trends pertain only to Hartsells topsoil and subsoils, where triticale, wheat and rye growth was increased, and Dickson topsoil, where triticale responded to lime. Increasing the lime rate increased the Mg and decreased the K, Al and Mn concentrations in plant tops. In Hartsells subsoil the Ca concentration in triticale and rye increased with growth due to liming but the K composition of triticale grown in this soil was not affected by liming. Since unlimed Hartsells soils contained less exchangeable Ca than unlimed Dickson soils (Table 1), Ca deficiency appears to have been one of the factors limiting plant growth in Hartsells soils. Hartsells subsoils had the least amount of exchangeable Ca and the highest growth responses to lime.

Table 5

Effects of liming Hartsells and Dickson topsoils and subsoils on the Al and Mn concentrations in plant tops

Soil	Lim appliee mt/d*	Al			Mn		
		Triticale	Wheat	Rye	Triticale	Wheat	Rye
		ppm					
		Topsoils					
Hartsells sl	0.0	301	471	346	213	279	236
Hartsells sl	3.3	243	145	117	96	100	144
Hartsells sl	6.6	147	140	165	67	71	56
Dickson sil	0.0	108	71	59	138	238	214
Dickson sil	3.9	72	59	52	80	67	83
Dickson sil	7.8	78	74	71	50	50	35
LSD (0.05)			141			55	
		Subsoils					
Hartsells sl	0.0	922	1,107	807	207	166	183
Hartsells sl	3.3	774	873	628	135	110	144
Hartsells sl	6.6	900	713	432	100	66	85
Dickson sil	0.0	690	386	402	594	356	307
Dickson sil	3.9	380	302	302	113	200	82
Dickson sil	7.8	318	363	250	57	57	69
LSD (0.05)			373			80	

* Lime recommendations were 6.6 and 7.8 mt/ha, respectively, for Hartsells and Dickson soils.

Adams—Henderson (1962) classified Hartsells soil with an exchangeable value of 0.16 meq/100 g as Mg-deficient and considered 0.20 meq/100 g exchangeable Mg in Dickson soil to be sufficient for clover and sudangrass. The natural exchangeable Mg values in the lime-responsive Hartsells topsoil, Dickson topsoil and Hartsells subsoil were 0.29, 0.26 and 0.07 meq/100 g, respectively, compared with 0.14 meq for non-responsive Dickson subsoil. These data suggest Mg was not one of the primary growth-limiting factors in these soils, except in Hartsells subsoil where plants had a relatively very low Mg concentration (Table 4). However, Soileau *et al.* (1969) found Ca and Mg deficiency in cotton in Dickson subsoil with exchangeable values of 1.0 and 0.4 meq/100 g, respectively. Potassium did not appear to be limiting plant growth in the present study since exchangeable K decreased with liming (Table 1) while growth increased except in limed Dickson subsoil (Table 2).

Manganese toxicity was not likely to be limiting plant growth because limed topsoils and subsoils contained similar amounts of exchangeable Mn. The main differences in the lime responses obtained appeared to be due to differences in exchangeable Al. The relative growth responses to the recommended lime rates were Hartsells subsoil $\times$ Hartsells topsoil $\times$ Dickson topsoil × Dickson subsoil (Table 3). The corresponding exchangeable Al values in these soils were 2.33, 1.25, 0.83 and 0.74 meq/100 g (Table 1). Additionally, Al concentrations in tops were reduced by liming Hartsells topsoil and subsoil with plants grown on the latter soil having a much higher Al level than those from the topsoil. No similar reductions in plant Al levels were caused by liming Dickson soils. These data indicate that Al was one of the primary factors or the major factor limiting plant growth in Hartsells soils, especially in the subsoil.

*

Prepared at the Department of Natural Resource and Environmental Studies Alabama A and M University, Normal, Alabama

V. R. PEKETI, L. M. MUGWIRA

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EFFECT OF UREA NUTRITION ON SEEDLINGS, PLANT GROWTH, FLOWERING TIME AND YIELD OF SWEET PEPPER (CAPSICUM ANNUUM L.)

The different effects of NPK levels on vegetable growth, composition, yield and fruit quality have been studied intensively. A few of the many reports on this subject are those by MILLER (1961), PIMPINI *et al.* (1971), THOMAS—HEILMAN (1967) and WALLACE—ASHCROFT (1956). The most important differences in nitrogen forms is that the ammonium ion competes with cations for absorption while the nitrate ion competes with anions. Few studies have been made on urea as a source of nitrogen.

TISDALE—NELSON (1975) tend to consider the uptake of urea as ammonium cation, because of its rapid hydrolysis to ammonia and carbon dioxide in the soil according to the equation:

$$CO(NH_2)_2 + 2H_2O \xrightarrow{\text{urease}} (NH_4)_2CO_3 \xrightarrow[\text{decomposes}]{\text{rapidly}} \text{ammonia} + CO_2$$

This hydrolysis of urea in the soil is responsible for ammonia injury to seedlings, if large quantities of this material are placed with or too close to the seeds. DROSDOFF *et al.* (1956) demonstrated that urea toxicity may be caused by biuret. This biuret is formed during the manufacture of urea when the temperature rises above a certain level. Biuret is toxic and when the content of this compound in the urea is too high, injury to plants will result. ALMÁSSY *et al.* (1977) reported that urea fertilizer contains at least 1—1.5% biuret.

On the other hand, WALLACE—ASHCROFT (1956) and HENTSCHEL (1970) indicated that much of the urea would be available to plants as urea. This result means that urea is taken up as an intact molecule and is transported as such in the xylem. However, TISDALE—NELSON (1975) suggested that the proper placement of the fertilizer urea with respect to the seeds may overcome this difficulty and that the hydrolysis of urea can be altered by using urease inhibitors. These inhibitors inactivate the urease enzyme and thereby prevent the rapid hydrolysis of the urea when it is added to the soil. The unfavourable effects of NH_4-N and urea-N on tomato, cauliflower and tung trees are reported by some authors (MAYNARD *et al.* 1966, PIMPINI *et al.* 1971, DROSDOFF *et al.* 1956) and the favourable effect of NO_3-N was studied by others (PIMPINI *et al.* 1971, WALLACE—ASHCROFT 1956).

This paper is an attempt to study the effect of different forms of nitrogen: ammonia, nitrate and urea, on sweet pepper growth and development, with different N-levels and day temperature, under greenhouse conditions, in sand culture and on clay-loam soil. The data illustrated in this paper were obtained in the summer season of 1975 on a sandy soil. The same trend was obtained in other seasons (1976, 1977) and high levels of urea fertilizer, such as 30 and 40 mg N per 100 g sand, showed a more toxic effect on pepper plants.

Experiments were conducted in 1975, 1976 and 1977 in the Soroksár experimental farm of the University of Horticulture, Budapest. The effects of different forms of nitrogen (NH_4^+, NO_3^- and urea) were studied in pot experiments in the greenhouse. Nitrogen doses of 10, 20, 30 and 40 mg N per 100 g soil were applied as nutrient solution on four occasions to clay-loam and poor sandy soil containing 1 mg N, 1.3 mg P_2O_5, 1 mg K_2O and 6.5 g $CaCO_3$ per 100 g sand. The soil pH was 7.58 for the sandy soil and 7.25 for the clay-loam soil.

In 1977 the effect of N-forms was studied on sandy soil under controlled day temperature conditions: 18 ± 3 °C and 25 ± 3 °C. Two sweet pepper varieties, cv. "Soroksári Hajtató" (white fruit) and cv. "Paradicsom alakú zöld" (tomato shape, red fruit), were used for this experiment.

The seeds of sweet pepper cv. "Soroksári Hajtató" were sown on 25th April 1975 in a fertile soil mixture. When the seedlings had developed the first pair of leaves (at 25 days of age) they were transplanted into five-litre plastic containers 22 cm in depth, and filled up with 9 kg of soil. For sandy soil a closed system of irrigation has been designed to provide the pots with water automatically as shown in Fig. 1. In 1977 the pots were replaced by black polyethylene containers 20 cm in diameter and 22 cm in depth, which were normally irrigated daily with tap water.

All nutrients were applied in the form of nutrient solution, with different rates of N (10, 20, 30 and 40 mg N/100 g soil) and constant P (20 mg P_2O_5/100 g soil), K (20 mg K_2O/ 100 g soil) and Mg (3 mg Mg/100 g soil) levels. However, the 1975 experiment included only

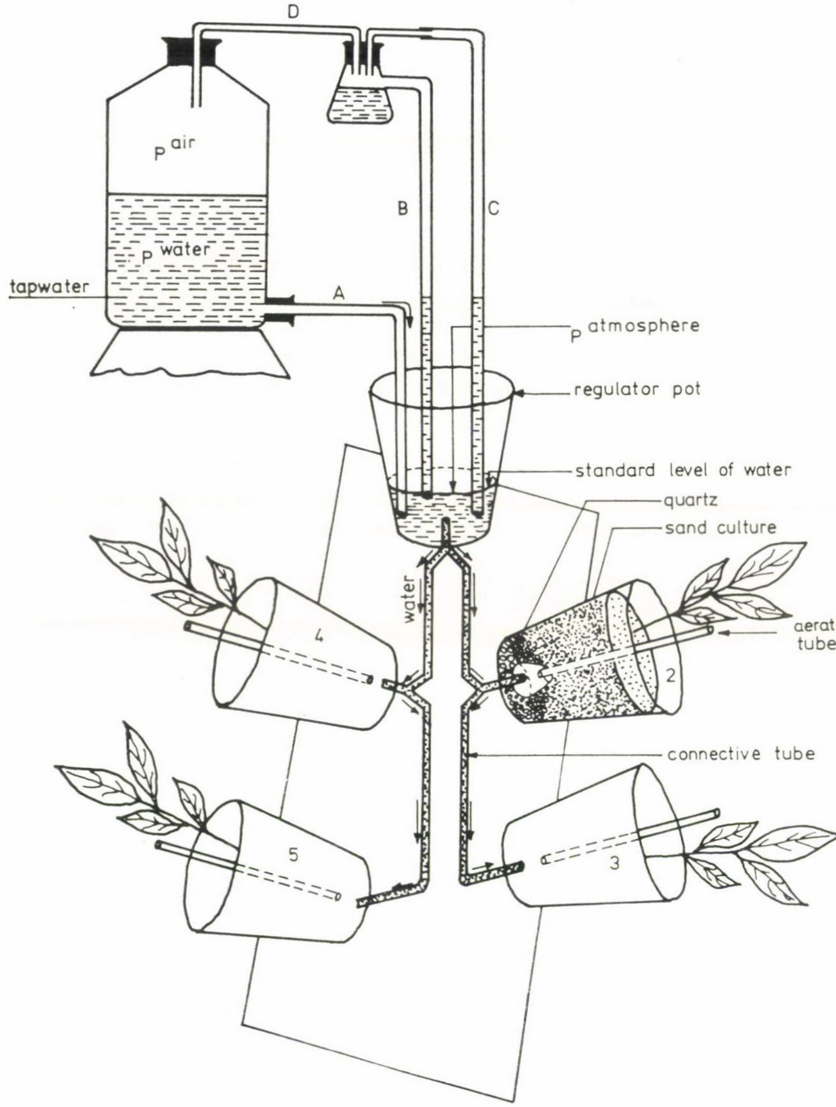

Fig. 1. System of irrigation

2 nitrogen levels: 10 and 20 mg N/100 g sand. Microelements were only applied to the sandy soil and at a standard level. All nutrient applications were given in a proportion of 40% at transplanting and 20% three times at three-week intervals. The NO_3^- and NH_4^+ sources were $Ca(NO_3)_2 \cdot 4\ H_2O$ and $(NH_4)_2SO_4$ for all experiments. The urea source was normal urea fertilizer (46% N) in 1975, while the chemical compound $CO(NH_2)_2$ was used in the other seasons. Generally the P and K sources were KH_2PO_4 and K_2SO_4, whereas Mg, Fe, Zn, Cu and Mn were added as sulphates, B as borax and Mo as $NaMoO_4 \cdot 2\ H_2O$.

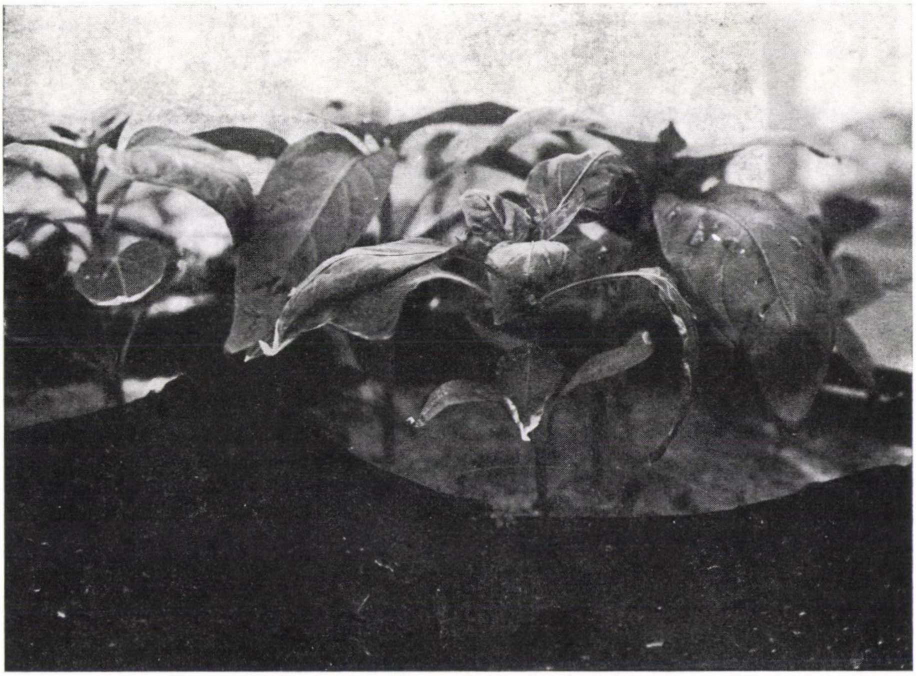

Fig. 2. Application of urea-N nutrient solution injured the leaves of seedlings. 20 mg N-urea/ 100 g sand, hot season of 1977 (25 ± 3°C)

Six plants were transplanted into every pot or container. At flowering time only two plants were left for yielding, while four plants were removed for chemical analysis. Experiments in a split-plot design with 4 or 6 replications were laid out in the summer seasons of 1975, 1976 and 1977. The temperature was conditioned near to optimum, and irrigation and other practices were also taken into consideration. The effect of different N-forms on the standing of pepper seedlings was observed and ammonia injury was registered. Plant growth was evaluated by plant height, leaf area, and fresh and dry weight of the leaves. The number of days from transplanting to anthesis of the first flower was registered for the individual plants. Data on early and total yield were recorded.

Sweet pepper seedlings at the first leaf-pair stage (25 days of age) were injured by all doses of urea-N, but not by NO_3-N or low and medium doses of NH_4-N. The blade edges of the 1st, 2nd and 3rd pairs of normal leaves were burned and dried (Fig. 2). After the 4th leaf stage, the new leaves were healthy. This injury started 7—10 days after the application of urea nutrient solution. The injury may be explained by the effect of ammonia released from the rapid hydrolysis of urea in the soil (TISDALE—NELSON 1975). In a soil poor in colloids, with low exchange capacity and definite placement, such as in the case of sandy pot cultures, ammonia injury was recorded (MAYNARD *et al.* 1966).

The lesions resulting from urea toxicity were severe and more pronounced in the case of sandy soil and high temperature (25±3 °C) than at lower temperature (18±3 °C) and in clay-loam soil. This may be explained by the high exchange capacity of the clay-loam soil, due to its high colloidal content, compared to that of the sandy soil. This is responsible for the rapid adsorption of the ammonia released from the urea hydrolysis. Furthermore, high

Table 1

Leaf development of cv. "Soroksári Hajtató" evaluated at the flowering stage (49 days after transplantation) in sandy soil
Soroksár, 1975

N-treatments mg N/100 g sand	Leaf dry wt., g/plant	Leaf dry matter, %	Leaf area,* cm²/plant
10 mg $N-NO_3$	1.186	12.89	469.525
10 mg $N-NH_4$	1.000	12.59	464.575
10 mg N-urea	0.979	11.32	418.550
20 mg $N-NO_3$	1.222	13.35	459.625
20 mg $N-NH_4$	1.276	13.09	415.340
20 mg N-urea	0.840	11.87	300.375

* Calculated for one leaf surface only.

temperature activates the urease enzyme in the soil leading to a more rapid hydrolysis of urea than at lower temperature.

It has also been noticed that seedlings and young plants were injured more seriously by urea-N than mature plants. However, the cv. "Soroksári Hajtató" proved to be more sensitive to urea application than the cv. "Paradicsom alakú zöld". Moreover, symptoms of urea toxicity were only observed on the cv. "Paradicsom alakú zöld" on sandy soil and at high temperature, but not on clay-loam soil.

Urea-N significantly decreased the dry matter yield of leaves by about 25 and 32% as compared to NH_4-N and NO_3-N respectively (Table 1). This decrease amounted to about 21 and 58% if the leaves were evaluated 63 days after transplantation. Evaluation in the first and in the second month after transplanting indicated that urea-N resulted in the lowest dry weight, dry matter percentage and leaf area among the nitrogen forms applied, as shown in Table 1. The data indicated that urea-N application depressed the leaf area of the plants by about 10 and 12% and 38 and 53% compared to NH_4-N or NO_3-N at levels of 10 and 20 mg N per 100 g soil, respectively.

The plant height of the cv. "Soroksári Hajtató" was about 40—47 cm and 45—50 cm for low and medium N-levels, respectively. During the period of 8 weeks after transplanting the plants treated with urea-N were shorter in growth than those which received NO_3-N or NH_4-N.

The data from the 1976 and 1977 seasons indicated that in high doses the ammonium nutrient solution had a toxic effect on pepper seedlings, especially in sandy soil. In the 30 mg NH_4-N treatment the plants received 12 mg NH_4-N per 100 g sand (40% of the total dose) at the first application, and this dose at one time proved to be very toxic to seedlings of the two pepper varieties tested. However, the dose of 12 mg of NO_3-N per 100 g sand was tolerated by pepper seedlings with no injury, as shown in Fig. 3. The toxicity of ammonia has also been reported for tomato (Maynard *et al.* 1966) and beans (Wallace—Ashcroft 1956). For pepper seedlings all doses of urea-N were relatively toxic and the highest tolerated dose of NH_4-N or urea-N, applied at one time, was 8 mg N per 100 g sand in sandy soil and 12 mg N per 100 g soil in clay-loam soil.

Generally, urea-N retarded the growth and anthesis of pepper plants more distinctly than NO_3-N and NH_4-N (Tables 1 and 2). In the 1975 season plants in the NH_4-N treatment

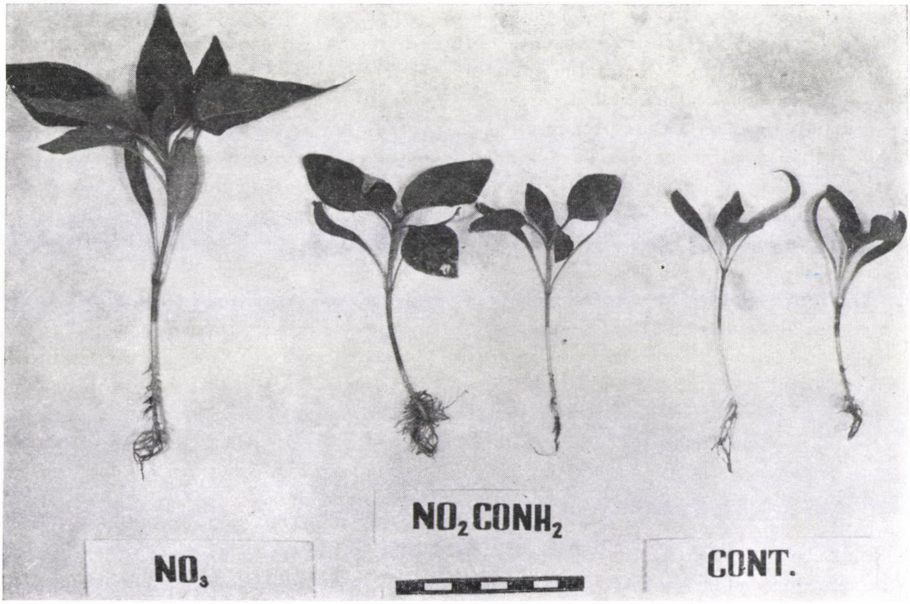

Fig. 3. Effect of N-form (20 mg N/100 g sand) on the growth of sweet pepper cv. "Soroksári Hajtató" 3 weeks after transplanting, Soroksár 1977

Table 2

Early and total yield and flowering time of cv. "Soroksári Hajtató" as influenced by N-forms and N-levels, in sandy soil Soroksár, 1975

Treatments	Early yield, first picking 31st July g/pot*	Total yield 31st July to 16th September g/pot*	Anthesis of 1st flower**	Number of days from transpl. to anthesis***
10 mg $N-NO_3$	81.1	130.8	18. VI—1. VII	35
10 mg $N-NH_4$	93.6	93.6	17—26. VI	32
10 mg N-urea	51.1	86.2	23. VI—3. VII	39
20 mg $N-NO_3$	65.1	182.6	22. VI—2. VII	38
20 mg $N-NH_4$	71.7	212.3	24. VI—3. VII	39
20 mg N-urea	53.2	193.8	25. VI—5. VII	41
L.S.D.$_{5\%}$				
N-level	N.S.	77.4		
N-form	22.48	N.S.		
Level × form	N.S.	N.S.		

* Each pot contained 2 plants.
** Date of opening of the 1st flower.
*** Seedlings were transplanted on 20th May 1975 (at 25 days of age).

reached anthesis of the first flower 7 days earlier than those in the urea-N treatment, within the low N-level range. Unpublished data obtained by the author indicate that high doses of urea-N, especially 40 mg N per 100 g soil, greatly retarded the growth of the cv. "Soroksári Hajtató" and decreased the yield to a greater extent than 20 and 30 mg N per 100 g soil. The conclusion was drawn that urea resulted in severe injury at high doses of nitrogen applied to sandy soil in a warm season. Urea-N decreased the early yield of sweet pepper by about 40.0—58.6% as compared with NH_4-N and NO_3-N application (Table 2). The total yield, however, was not influenced by the N-form. Total yield increased about 1.71, 2.26 and 2.24 times by increasing the NO_3-N, NH_4-N and urea-N levels from 10 to 20 mg N per 100 g sand, respectively, as shown in Table 2.

The data on the N, P and K content of the leaves are presented in Table 3. The total-N percentage and the total-N accumulation in pepper leaves greatly increased when the levels of NH_4-N and urea-N were increased, whereas increased levels of NO_3-N only slightly increased the total-N content of the leaves. This result agrees with those of PIMPINI *et al.* (1971) in experiment on cauliflower. Although the total-N percentage was 5.54% and 3.74% in the leaves of plants fertilized with urea-N and NO_3-N, respectively, there was no difference in the total-N accumulation per plant (Table 3). The explanation may be found in the early translocation of the element from the leaves to the early fruit set in NO_3-N plants, and by the injury and abscission of 2—4 older leaves in urea-N plants.

Plants which received 10 mg NO_3-N per 100 g sand contained 0.87% P in the leaves. Only the high dose of 20 mg NO_3-N decreased the total-P accumulation greatly, its percentage in the leaves amounting to 0.44% P, with a highly significant difference compared to all the N-treatments (Table 2). This result may be due to the competition between NO_3^- and PO_4^- at high concentrations of nitrates. Similar results were reported by WALLACE—ASHCROFT (1956)

Table 3

N, P and K content in leaves of cv. "Soroksári Hajtató" as influenced by N-form and N-levels, in sandy soil culture. Evaluated 49 days after transplanting
Soroksár, 1975

Treatments	Percentage of element in leaf dry matter			mg element/plant			Total N + P + K mg/plant
	N	P	K	N	P	K	
10 mg N—NO_3	3.32	0.87	4.88	39.38	10.32	57.88	107.58
10 mg N—NH_4	2.39	0.83	4.36	23.90	8.10	43.60	75.50
10 mg N-urea	3.32	0.84	5.83	32.50	8.22	57.08	97.80
20 mg N—NO_3	3.74	0.44	5.23	45.70	5.38	63.11	114.21
20 mg N—NH_4	5.52	0.68	5.31	70.44	8.68	67.76	146.88
20 mg N-urea	5.54	1.04	5.85	46.54*	8.74	49.14	104.45
L.S.D.$_{5\%}$							
N-level	0.69	N.S.	N.S.				
N-form	0.28	0.18	0.55				
Level × form	0.39	0.25	N.S.				

* The 1st, 2nd and 3rd leaves were injured by urea-N leading to a decrease in leaf number and green and dry weight.

and PIMPINI *et al.* (1971). On the other hand, urea-N induced a higher increase in the P percentage in the leaves than other nitrogen forms. This may also be explained by the translocation of P from the leaves to the early fruit set developed in NO_3-N and NH_4-N plants.

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Prepared at the Institute of Vegetable Growing, University of Horticulture, Budapest

M. R. GABAL

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FORUM

OUR GUEST IS

DR. JÁNOS LELLEY

RETIRED SCIENTIFIC HEAD OF THE WHEAT BREEDING DEPARTMENT AT THE CEREAL RESEARCH INSTITUTE, SZEGED

PÁL, GY.: *Mr Lelley!*

The biological value of wheat proteins is determined by the quantities of essential, non-essential and prevalent amino acids contained in the wheat grain. But the composition of proteins of animal origin is more similar to those which make up the human organism, so the higher the level of nutrition in a country, the larger the proportion of animal protein in the diet. Do you think the biological value of wheat proteins should be increased by breeding, or is it preferable to produce biologically valuable proteins via animals by feeding wheat varieties with higher productivity but lower biological value ?

LELLEY, J.: **Prior to answering the question I should like to comment on the introductory statements.**

It is a fact that in countries with high living standards the population consumes more food of animal origin. Not because these people have a wider knowledge of nutrition biology, but simply because they can afford to prepare a greater variety of tastier but more expensive meat or dairy dishes, if for no other reason than that the necessary

ingredients are readily available. Thus, such a change in the diet is primarily the consequence of a rise in the living standard, although it must not be forgotten that large volumes of meat and animal products are consumed by peoples living under primitive conditions in cold, or even in hot dry zones where livestock farming forms their livelihood.

Research on human nutrition biology is a relatively young science; the significance of vitamins, the role of essential amino acids, the importance of unsaturated and saturated fatty acids, or the difference between natural and crystalline carbohydrates have only been discovered during the last few decades. And the time when this knowledge will become public property is still very distant. In fact, we are just beginning to find out what the healthiest type of nutrition for Man is, and even today there are a lot of uncertainties and contradictions. It will suffice to mention the complicated cholesterine question, or the controversies about animal and vegetable fats.

There is one thing that is unfortunately still not taken into consideration during research into nutrition biology, namely, that genetically, anatomically and physiologically man is a typical omnivore. Under normal life conditions the food of omnivores is mostly of vegetal origin, the relatively small quantities of animal proteins and fats which complement their diet only serving to supply the essential amino acids not to be found in vegetal proteins. This indisputable fact suggests that consuming a large quantity of food of animal origin cannot be biologically advantageous for humans. Today this fact is beginning to be acknowledged; experts from countries with a developed nutrition culture call attention more and more frequently to the correlation between excessive meat consumption and articular and vascular disorders.

There can be no doubt that the consumption of food of vegetal origin, particularly of cerals, involves the uptake of superfluous carbohydrates. These surplus calories should be utilized by physical work or sport. However, technical development has almost totally eliminated physical work. In the highly industrialized countries the overwhelming majority of people do nor muscular work, no do they walk any more. Under such conditions the ratio of protein to carbohydrate in cereals is certainly not favourable, although some decades ago, when the bulk of the work was done by hand, it was almost ideal. The protein–carbohydrate ratio of wheat, which was so favourable a short while ago, has now become a disadvantage, as it results in an increase in body weight. It would therefore be desirable to increase the protein content of cereals at the expense of carbohydrates.

After this introduction my answer to the question is self-evident. All the biological conditions indicate that one of the most important tasks facing wheat breeders is to increase the total protein content of this high priority bread grain. In this way the ratio of protein to carbohydrate could be modified, and if the missing essential amino acids were simultaneously supplied the biological value of wheat protein would come closer to that of animal protein. It would be a mistake to promote the cultivation of wheat varieties with high productivity but low protein content with a view to using them as fodder and thus producing more animal protein. In any case, transformation by animals is not advantageous, because owing to the loss of energy and material it is less profitable, even if wheats with a high protein content yield somewhat less than the protein-deficient fodder wheats.

I should also like to call attention to another point.

The world-wide demographic explosion is continuing almost unchanged. For the time being no one can predict when this process will slow down or stop. In a few decades time the world population will be so high that, apart from waste products, hardly any grain suitable for human consumption will be available for feeding purposes.

We shall soon arrive at the point where only crops which are totally useless as human foodstuffs are utilized by animals, and grassland management is restricted to areas completely unsuitable for crop production. This is no Utopia, having long since been the case in some overpopulated parts of China and India. With such a perspective it would be a mistake to expect exactly the opposite.

A considerable increase in the total protein content and an improvement in the amino acid composition of wheat varieties can be achieved without any great sacrifice in terms of productivity. Recent experiences show this quite clearly.

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PÁL, GY.: *Recently varieties have been changed too frequently in wheat production. In the course of this process varieties which are resistant to diseases come more and more into prominence because the cultivation of resistant and tolerant varieties increases the reliability of production and also improves the economic efficiency of wheat production. Most varieties recently included in commercial production owe their popularity to their disease resistance, as well as to their high yield potential. In your opinion, is it possible to introduce new varieties so rapidly that the pathogens are no longer able to accommodate themselves to the new varieties, i.e. can new varieties be evolved more rapidly than new pathogen biotypes?*

LELLEY, J.: The replacement of varieties takes place more rapidly now than it did a few decades ago, but not everywhere as rapidly as in Hungary.

One reason for this is that there are a lot more wheat breeding centres now; furthermore, considerably more genetic knowledge is available and the methods employed are more developed. Any plant breeding institution carrying out systematic, scientifically based wheat breeding should come up with competitive experimental varieties in 8–10 years at the latest. And if they continue to exploit the possibilities after this initial period, they will be able to produce further experimental lines to compete with their own varieties, as proved by the example of the Agricultural Research Institute of the Hungarian Academy of Sciences at Martonvásár, or the series of successes achieved by the research institute of the agricultural college in Novi Sad.

Another reason for the more frequent change of variety is that as a result of the mechanization and consequent partial standardization of soil cultivation and plant tending, and of the general use of intensive fertilization, the importance of differences in quality between soils has decreased, and even the influence of climatic factors has diminished. As a consequence, wheat varieties are able to compete on an ever increasing area. At the same time, breeding for ecological adaptation has also become an objective, since there are financial interests involved in growing the varieties on as large an area as possible.

Hungary is a small country and falls within a climatic zone of Europe that extends far beyond its borders. It is not surprising, therefore, that winter wheat varieties produced in the neighbouring countries are rivals to those bred in Hungary. This circumstance also contributes to the acceleration of variety replacement.

Alterations in the biological races of pathogens and the speed at which they spread are not closely connected with the conditions outlined above. It has only happened once in Hungary that a wheat variety had to be excluded from commercial production because of mass infection by a new rust race. In almost every case varieties have had to be replaced because new winter wheat varieties, which were perhaps hardly more resistant but were more productive, appeared in the variety trials of various countries.

In Hungary the frequency of variety replacement will be determined by yield potential for some time to come. Under the climatic conditions of Hungary genetic changes in the pathogens are not yet a decisive factor in the success of wheat production. It is possible, however, that within a decade or two the potential productivity of the wheat varieties will come close to the upper limit that the genus Triticum is biologically able to reach. Such an upper limit does exist. If this occurs the life of each variety will be longer again, and genetic changes in the pathogen races may become a more important factor.

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PÁL, GY.: *Between 1961 and 1965 the world wheat yield average was 1.2 ton/ha, while the Hungarian average was 1.86 ton/ha, i.e. 50% higher. In 1977 the world average was 1.66 and the Hungarian average 4.05 ton/ha, i.e. the average wheat yield in Hungary exceeded the international average by 144%. Harvesting a wheat area of about one and a quarter million hectares at the right time and without losses raises considerable problems for the Hungarian farms. Do you think the number of machines used for harvesting should be increased in order to shorten the harvesting period, or should the harvesting period be prolonged by choosing varieties which mature at different times ?*

LELLEY, J.: Harvesting in a short time without loss has priority over everything else. The stock of machinery should therefore be increased and kept at the necessary quantitative and qualitative level, and the range of varieties grown in a farm should be chosen so as to render it possible to complete the wheat harvest within a few days. In this case no major problems will arise even if the weather conditions are unfavourable. Thus, the two solutions mentioned should both be employed.

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PÁL, GY.: *The United States of America supplied 48% of the world export of bread wheat and 61% of fodder grain in the 1976—77 crop year, at a time when farmers were given financial compensation for leaving 20% of the bread wheat area and 10% of the fodder grain area fallow or for growing other crops on the land, though of course it was generally land with lower productivity that was left uncultivated or sown to crops other than wheat. Do you think that an overproduction of wheat, causing a crisis similar to that in 1929 and the subsequent years, may occur in Hungary ?*

LELLEY, J.: If the favourable climatic and soil conditions are taken advantage of to concentrate on the cultivation of high quality wheat, a crisis caused by overproduction need not be feared. Owing to the ever increasing demands for food, high quality wheat surpluses will always fetch a good price. If, on the other hand, the aspect of quality is neglected and large yields are given priority, it may happen that part of the surplus will have to be fed to poultry or young animals, as the world market price for poor quality wheat will not be satisfactory.

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PÁL, GY.: *The yield components of wheat are the number of productive ears/m^2, the number of grains/ear and the average grain mass. The number of ears/m^2 is determined by the density of sowing and the extent of tillering. With a higher stand density the crop will not become overgrown with weeds but the danger of pathogens appearing because of the closed micro-*

climate increases, while lowering the stand density involves the danger of weed growth. In your opinion, taking into consideration the effect of the weather, does the appearance of pathogens or the overgrowth of weeds represent a greater danger to the wheat stands at present?

LELLEY, J.: Highly effective chemicals are now available for the control of weeds. Chemical weed control is a cultural practice that every wheat grower must be familiar with and apply properly. There is no excuse for those who neglect it or carry it out incorrectly. Weed control is a routine operation obligatory for every wheat grower.

As far as pathogens are concerned, farmers are almost helpless, since conditions favourable for wheat are just as favourable for pathogens. Disease control is therefore the exclusive responsibility of the breeders. Resistance to leaf and stem rust, powdery mildew, Fusarium, and perhaps to foot-rot must be genetically established. Most of the current wheat varieties already possess some resistance or tolerance, though the protection they give is far from being perfect. On the other hand, varieties which are particularly susceptible to diseases are not cultivated anywhere. This does not mean that the protection from diseases is generally satisfactory; breeders still have a great deal to do. It is very unlikely that complete, general pathological resistance within a single variety will ever be achieved. The probability of yield loss caused by diseases will therefore always be higher than the likelihood of damage by weeds, provided farmers carry out the necessary weed control.

*

PÁL, GY.: *In his work "Hitel" (Credit) István Széchenу, a prominent figure in Hungary in the 19th century, wrote in 1831: "The price of wheat has been known to go up to 20 forints per vat (25 gallons), and with it the price of boots too, but then, when wheat drops back to 5 forints, the boots are still way up in the clouds and only come down slowly". The interrelation between industrial and agricultural prices in the course of time is shown by the so-called agricultural price gap. When agriculture was based on small peasant farms the agricultural price gap was closed when 1 q wheat was equivalent to a pair of boots. Today approximately 5 q wheat is equivalent to a pair of boots. What do you think is the reason for this wide agricultural price gap in the case of wheat?*

LELLEY, J.: It is not only for wheat that the agricultural price gap is so wide; this is the case for all agricultural produce. The reason for this phenomenon is that although mechanization replaces a considerable part of the animal and human labour it is by no means cheaper; on the contrary, the production costs are higher now than they were in the past. They are higher than they were when the work was done by draught animals and man power. Since the industry-centred view still prevails, the prices are fixed by industry, and agriculture is more and more dependent on the machinery and chemicals produced by industry, so the agricultural price gap remains wide in spite of the fact that everybody, including the industrial workers, lives almost exclusively on agriculture.

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PÁL, GY.: *The size of the yield is determined by the production potential of the variety, the agrotechnical level and the sensitivity of the variety to the cultural practices employed. Owing to the increasing rate of fertilization per unit area extensive plant varieties will be replaced by intensive types, while the extension of the irrigation area and the trend of the climatic factors will result in humid type varieties being substituted for arid type ones. With the* *current wheat varieties and hybrids grown in Hungary, what in your opinion is the ton/ha value up to which the yield is due to cultural practices and above which it depends on the variety ?*

LELLEY, J.: This is an extremely difficult question to answer. It is a well-known fact that without adequate hereditary characters any agrotechnical intervention is useless, as good results cannot be achieved. It is also true, however, that no wheat variety gives large yields without the right methods of soil preparation, fertilization, sowing, plant tending and harvesting, even when endowed with the most excellent hereditary characters. Whether the question is put to farmers or breeders the answer will be prejudiced, and this is quite natural. I will not undertake to determine the numerical shares of the two parties either, since in my opinion it is an impossible task.

The characters of winter wheat varieties, such as hereditary winter hardiness, drought resistance, ecological adaptability, standability, pathological resistance, total protein content, baking quality and even the potential productivity, evolve during the breeding process. The achievement of these characters in practice, however, depends on the farmer. Thus, in my unprejudiced opinion, both functions are equally important for complete success. This is why the two cannot be compared numerically, though a certain kind of evaluation is still possible, as may perhaps be made clear by an analogy.

The interpretation of a Mozart sonata may be either good or poor. It may be a complete success, but it may also be very mediocre. Nevertheless, Mozart's reputation will not be impaired even if the pianist is untalented. This is the difference between creation and interpretation. Both are indispensable, they postulate and complement each other, yet the two activities are not of the same quality. This analogy will give some idea of the equality and interdependence of the work of breeders and farmers, but also of the difference in quality between the two.

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PÁL, GY.: *By the end of this century some 8 thousand million people will be living on the Earth. Assuming a 3% annual increase in the per capita energy consumption the energy requirement will be five times what it is now. The reduction in energy supplies and the steady increase in energy prices will also make their effects felt in agricultural production. Drying is one of the most important energy-consuming agricultural operations. In your opinion, can the very energy-intensive drying of wheat crops be replaced by late harvesting ?*

LELLEY, J.: As I have already mentioned, farms should be equipped with a sufficient number of combine harvesters and transport facilities, and the varieties should be chosen so as to ensure that wheat harvesting is completed within a few, say 6, workdays. In that case artificial drying will hardly be necessary. Care must be taken, however, to ensure that crops with somewhat higher moisture contents are cleaned at once and stored in such a way that after-drying can be carried out rapidly.

The provision of the technical conditions required for no-loss harvesting is in the fundamental interest of the national economy, since wheat provides bread for the country and is also an important export item. Before the introduction of mechanized harvesting the harvest was not a topic of general discussion, although in those days the crop was cut with a scythe, and the grain was threshed from ricks or stacks. The conditions required for mechanical harvesting must be optimized as soon as possible, so that it will no longer be a subject of concern in the newspapers.

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PÁL, GY.: *Wheat is one of the most important plants cultivated by Man. Bread made from wheat was a sacrificial object even in the most ancient religious ceremonies. The 12 tribes of Israel had to place 12 loaves of well-shaped tasty bread in two rows on the gold-covered portable shittim wood table in the sanctuary of the holy tabernacle every Sabbath. What do you think is the most feasible way of making good bread today: the genetic incorporation of good flour quality in a wheat variety of poor quality, or the elaboration of milling and baking technologies which will make it possible to produce good quality bread from poor quality flour?*

LELLEY, J.: Well-structured, tasty bread cannot be made from the flour of a hereditarily poor quality wheat even by chemical intervention and with the most up-to-date bakery equipment, not to mention the fact that making the baking technology more complicated is also costly, increasing the price of the product and decreasing the profit made by the bakery. Thus, making good bakery products from the flour of good quality wheat is not only simpler but cheaper too, so breeders must make every effort to improve the baking quality, a deterioration in quality during harvesting and storage must be prevented, and finally, conscientious work must be demanded from the milling and baking industries. However, the bakeries cannot be reproached if they are not supplied continuously with good flour of a uniform quality.

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PÁL, GY.: *The present aim of wheat breeding is to increase the yield potential, maintain or improve the quality, and develop resistance to unfavourable climatic conditions and diseases. The wheat varieties now under cultivation and those now being produced endeavour to meet these requirements. Since these characters are hereditary to a great extent, they can only be incorporated in the new varieties by breeding methods. Do you, as a prominent breeder, think that potential productivity, the maintenance or improvement of good flour quality, and resistance to unfavourable climatic conditions and diseases can be brought together in a single variety?*

LELLEY, J.: The hereditary characters of wheat varieties must now meet a wide range of requirements and the international competition is very strong, almost ruthless. At the same time, the results attained so far in plant breeding prove that climatic tolerance and pathological resistance can be combined with high hereditary yield potential without any difficulty. There is no negative correlation between these characteristics. That found to exist to some extent between semi-dwarfness and high productivity has recently been successfully eliminated.

My own experience shows that even the negative correlations experimentally proved by many researchers to exist between productivity and protein content and between productivity and baking quality can be overcome.

In the wheat variety Tiszatáj bred at Szeged, we have succeeded in overcoming these two negative correlations to a considerable extent. The total protein content of the variety is 16%, i.e. 20–25% higher than that of the well-known wheats previously produced in the Tisza region, which had high quality but low productivity, and its baking quality is no worse either. The upper limit of its potential productivity is about 70 q, which is hardly lower than that of the standard variety Martonvásári 4. Thus, the negative correlation has practically been overcome. The breeders must now systematically follow up this work.

As far as the improvement in the biological value of wheat protein and the increase in lysine content are concerned, the results so far are only fair. Fortunately there does not seem to be a negative correlation between the total protein content and the amount of lysine. A higher amount of protein does not mean it will have lower biological value. Judging by the experiences outlined above I am convinced that a break-through will be made here too, although it is possible that in this case success can only be expected from induced mutations. And since the prospects of this method of breeding always depend on chance, steady hard work will be required if the lysine content is to be increased, thus raising the approximately 60% biological value, i.e. digestibility of wheat protein to the level of animal proteins.

In my opinion the prospects for a quantitative and qualitative improvement in wheat protein are favourable. I am sure the geneticists and breeders will manage to solve this problem, in which case wheat flour will become a basic foodstuff containing less carbohydrate and more protein, thus better suited to modern requirements.

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PÁL, GY.: *Thank you for the information.*

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CHRONICA

THE AGRICULTURE OF THE MEZŐFÖLD BETWEEN 1938 AND 1944

1. The Mezőföld as a regional unit. General characteristics

The Mezőföld is a geologically and geographically distinct regional unit of Transdanubia, the western part of Hungary. It is bordered on the northeast and north by a sunken hill ridge at Érd, the valley and upper reaches of the Benta, a stream flowing into the Danube, and the valley of the Sajgó stream. On the northwest it is bordered by the edge of the Vértes and Bakony hills as far as Fűzfő Bay, which forms the northeastern corner of Lake Balaton; on the west by the shore of Lake Balaton between Balatonfűzfő and Siófok; on the south by the tectonic erosion valley of the Sió Canal as far as Simontornya and then by the terrace field extending to Dunaszentgyörgy; and on the east by the steep bench that forms the western bank of the Danube (ANONYMOUS 1959). The regional unit measures 124 km in a north–south and 70 km in an est–west direction; excluding the Velence hills, which form an island in the regional unit, the Mezőföld has an area of 4500 sq.km. The average height is 120—180 m above sea level, and the region consists of plains and rolling hills; its Pannonian layers are covered by thick loess (to a depth of 50 m at Paks, for example). The regional unit is divided into two parts (a smaller western part and a larger eastern one) by the valley of the Gaja and Sárvíz streams, which run roughly north—northwest to south—southeast. The valley, about 70 km long, is characterized by meadows and peat bogs (ANONYMOUS 1961).

Between 1938 and 1944 (unlike the present status which has been in effect since 1950) the larger part of the Mezőföld belonged administratively to Fejér county, while smaller areas came under Veszprém and Tolna counties. (At present almost the entire Mezőföld falls within the authority of Fejér county, except for a small southeastern corner which belongs to Tolna county.)

2. Distribution of landed property in the Mezőföld between 1938 and 1944

Not only Fejér county, which occupies most of the Mezőföld, but also the Enying district, which belongs to Veszprém county were perhaps the most characteristic large estate regions in Hungary in the mid-thirties. In order to win the peasantry over to its policies and icrease the number of peasants interested in the defence of private property, the Horthy regime which followed the 1919 proletarian revolution carried through a partial land reform between 1920 and 1931, in the course of which some 30,170 ha of land in Fejér county were distributed. Part of this (5950 ha of land in the form of 531 plots) was given to certain ex-servicemen as a reward for bravery during World War I. The rest (27,150 ha) was distributed among 24,710 individuals, which meant hardly more than one hectare per person (FARKAS, 1970a).

According to the 1935 statistical survey, the distribution of landed property in the Fejér county districts of the Mezőföld, including the city of Székesfehérvár, was as follows:

Dwarf-holdings: 54,291 (80% of the total number of farms), occupying an area of 40,835 ha (13% of the total agricultural area).

Small-holdings: 14,438 (18% of the total number of estates), occupying 122,450 ha (41.5% of the total agricultural area).

Medium-sized estates: 385 (0.7% of the total number of estates), occupying 71,700 ha (10.5% of the total agricultural area).

Large estates: 92 (0.2% of the total number of estates), occupying 184,750 ha (35% of the total agricultural area).

In the Fejér county districts of the Mezőföld there were 72 estates with an area of 300—600 ha each, and 91 estates which were larger than 600 ha each. These 163 farms occupied 60% of the agricultural area of the county (M.S.Sz. 1938).

The statistical data reveal that the average sizes of the dwarf, small and large estates were below the national average. There were, in fact, only two really large estates in the county: one at Előszállás and the other at Hercegfalva, both possessed by the Cistercian Abbey at Zirc; the joint area of the two exceeded 15,300 ha. The large area taken up by the large estates was due to the fact that there were relatively a lot more large estates of over 600 ha in the county than in other parts of the country. In Fejér county only the medium-sized estates had an average size larger (by 19.2%) than in other counties of Hungary. In 1937 the Upper Transdanubian Chamber of Agriculture, whose authority extended over the counties of Sopron, Vas, Veszprém and Fejér, published data on the yield averages, production area, production costs and net proceeds for landed properties in Fejér county. These showed that:

on estates larger than 60 ha, farmed entirely by wage earners:
— income in wheat equivalent: 692 kg, in monetary value: 131 pengös 50 fillers;
— expenditure in wheat equivalent: 673 kg, in monetary value: 128 pengös;
— net profit in wheat equivalent: 19 kg, in money: 3 pengös 50 fillers;

on estates between 60 and 12 ha, where some of the work is done by the family and the rest by wage earners:

— monetary value of yield:	112 pengös 50 fillers;
— production costs:	104 pengös 50 fillers;
net profit:	8 pengös;

on estates of less than 12 ha worked exclusively by the family with no help from wage earners:

— monetary value of yield:	112 pengös 50 fillers;
— production cost:	100 pengös;
net profit:	12 pengös

(F.M.K. Jelentése 1939).

The calculations of the net profit confirmed the view that it would be worth strengthening the small-holding peasantry by a certain amount of land reform. Landless farm servants, day-workers and dwarf-holders were excluded from the land distribution. The land reform carried out by Nagyatádi between 1920 and 1931 provided sufficient evidence that there was no point in increasing the number of unviable dwarf-holdings. In the summer of 1937 the subprefect of Fejér county made specific proposals for the land reform. Since the political direction of the county was then exclusively in the hands of owners of medium-sized estates they naturally suggested distributing entailed estates, church lands and large estates burdened with heavy debts. As a first step the subprefect wished to expropriate the 8075 ha entailed estate of Count Móric Esterházy at Csákvár, the 7300 ha estate belonging to Zirc Abbey at Előszállás, and Aladár Zichy's 2870 ha estate at Adony. According to the proposal, the distribution of these three large estates would have created a certain degrees of economic balance in 23 villages in Fejér county. The representatives of the large estates, particularly Gyula Hagyó Kovács, the manager of the Zirc Abbey estates, and the landowner Ferenc Hunyadi, tried to turn the government's attention from the great estates to the medium-sized estates farmed mainly by Jewish tenants and owners. In their opinion the production level of the medium estates and rich peasant farms was very low and could only ensure a very poor living standard for their workers and employees (Farkas 1970b). The first event in the land reform was when Ferenc Nádasdy had 1800 ha of his 3600 ha estate at Nádasladány parcelled out into allotments, to the great satisfaction of the land-owning peasantry. The selling off of the Csekonics estate at Enying began in the same year, 1938. The fact that this land, which was highly suitable for intensive farm management, was bought by the Hungarian Radio and not by the peasantry created a great scandal (F.M.K. Jelentése 1939). In the end nothing came of the land reform and it was only after the enactment of Act XV/1942, following the anti-Jewish law, that 67 Jewish tenants and landowners in 37 villages in Fejér County were compelled to give up some 12,000 ha of land (Farkas 1970b). This was followed by another 12,000 ha or so which was leased by Jewish tenants in the Székesfehérvár district.

3. Situation of agriculture in the Mezőföld between 1938 and 1944

A) *Situation of crop production in the Mezőföld between 1938 and 1944*

The distribution of the landed properties in the Mezőföld region according to the different branches of agriculture was surveyed in 1935 (M.S.Sz. 1939). The data show that, on average, in the Fejér county districts of the Mezőföld the dwarf-holdings were richer in gardens and vineyards and the small-holdings were richer in arable land, while the medium and large estates had large shares of the pasture and forest area.

The 284,171 ha arable area of Fejér county (67% of the total area) was distributed among the landed properties as follows: dwarf-holdings: 31,235 ha; small-holdings: 101,665 ha; medium-sized estates: 43,116 ha and large estates: 108,155 ha.

Owing to the nearness of Budapest as an outlet the utilization of the arable land differed somewhat from the national average: according to the 1937 data cereals were grown on only 43.8% of the arable area in Fejér county (compared to the national average of 50.8%). Furthermore, the cereal production on the large estates was lower than that on the dwarf and small-holdings. The commercial field crop production was also below the national average (0.9% compared to 1.1%) as was the production of vegetables (0.3% compared to 0.7% on a national scale).

The field production of legumes, row crops and roughage, on the other hand, was above the national average (1.8, 33.2 and 17.5% compared to 0.9, 30.6 and 12.3% respectively). The above-average production of row crops and roughage was due to the large number of livestock and the small natural grassland area of the county. Among the row crops the production of maize was considerable (in 1937 72,570 ha were sown to maize); a mixture of spring vetches was the most frequent roughage crop, but large quantities of lucerne, saintfoin, and green maize sown thickly for use as fodder were also grown (M.S.Sz. 1939).

a) *Cereal production between 1938 and 1944*

In the 1937 crop year agricultural production both in the Mezőföld and in the country as a whole showed a tendency to increase. In those districts of the Mezőföld which belonged to Fejér county, with the exception of the city of Székesfehérvár, a total 79,757 tons (1.35 tons/ha) of wheat, 26,927 tons (1.17 tons/ha) of rye, 25,909 tons (1.14 tons/ha) of barley and 15,609 tons (1.34 tons/ha) of oats was produced (M.S.Sz. 1939). Owing to the relatively high cereal production the export of cereals increased. The following quantities of cereals were exported from the Fejér county districts of the Mezőföld in 1937:
wheat: 1230 tons to Switzerland, 1020 tons to Austria, 255 tons to Italy, 5 tons to Denmark;
rye: 2645.4 tons to Austria, 45 tons to Finland, 30 tons to Holland, 15 tons to Switzerland (F.M.K. Jelentése 1939).

The 1938 crop year produced good cereal crops and good cereal prices. According to calculations by the Upper Transdanubia Chamber of Agriculture, the 1938 harvest resulted in higher yield averages. The average yield per ha was 200—300 kg higher on the large estates than in the dwarf and small-holdings. In the districts of Adony, Sárbogárd, Székesfehérvár and Vál 1816—1885 tons/ha was the average yield of wheat on farms measuring 3—60 ha, the only exception being the Enying district, where the yield average was 1954 tons/ha. In farms between 60 and 600 ha in size the wheat yield average was 2110—2410 tons/ha. (The wheat yield average was the highest on estates of over 600 ha in the Adony district.) In the same districts rye gave considerably lower yield averages irrespective of farm size: 1300—1780 tons/ha; the rye yield average was the lowest in the Vál district and the highest in the Enying district. The difference in yield between small and large estates, in favour of the latter, was reflected by the yield of barley as well. On farms of less than 60 ha the barley yield average ranged from 1314 to 1540 tons/ha, while on estates of 60—600 ha and larger barley yielded 1712—2024 tons/ha (F.M.K. Jelentése 1939).

In the autumn of 1938 the Ministry of Agriculture, in co-operation with the Upper Transdanubia Chamber of Agriculture, organized a 30 ton wheat seed loan for small farmers cultivating an arable area of less than 12 ha in the Fejér county districts of the Mezőföld (F.M.K. Jelentése 1939). At that time the insufficient number of horses (the consequence of mobilization against Czechoslovakia) was a great problem, since 30—40% of the horses were requisitioned. According to reports from Seregélyes, Sáregres, Nagylók and Rácalmás the shortage of horses caused serious difficulties in autumn ploughing and soil preparation (dung spreading). Fortunately, the wet, misty weather in December destroyed a large proportion (up to 80% in places) of the mice and voles that threatened the autumn sowings. And February 1939 was so mild that the farmers could resume the ploughing left unfinished in the autumn. In spite of the rainfalls in the summer of 1939 the cereasls only produced moderate yields: the wheat crop was good, but the rye, barley and oats produced very small grains. The agricultural work done in the autumn of 1939 was successful: the autumn sowings exhibited satisfactory development by December, the only significant damage being caused by mice in the neighbourhood of Székesfehérvár, carabic beetles in the district of Nagylók and nematodes in the vicinity of Rácalmás. However, the severe cold and snow in February 1940 severely damaged the autum sowings and hindered work in the spring. The hard winter resulted in devastating floods by April: between Ercsi and Adony many farms and animals were destroyed. In the district of Csákberény the autumn sowings of oats and barley were frozen out and there was a 30—40% loss of vetches. A considerable part of the winter crops was destroyed at Sáregres and Rácalmás too, though in other places, e.g. in the neighbourhood of Magyaralmás and Nagyveleg, they safely survived the winter. However, the floods and the persistent dampness of the soil greatly delayed the soil preparation and sowing in the spring. It was only in the region of Rácalmás that the May rains revived the dying crop. A large proportion of the winter barley had to be ploughed out and replaced with beet and maize. The situation was made still worse by the fact that the market prices for farm produce fell below the price of production: the price of rye in Budapest was 160—170 pengös per ton while a minimum price of 40 pengös/ton was paid for potatoes by the starch factories. The heavy rains on 17th June again did great damage to the grain crops; in many places the stands were lodged and there was a great danger of infection by rust. To make matters worse, owing to the political and military tension between Hungary and Romania, the calling up of men for military service and the requisition of horses and carts started again in July. In August and September there was an endless rainfall that hindered not only harvesting and threshing, but also the subsequent soil preparation and sowing. In the vicinity of Seregélyes, for instance, almost all the arable land and pastures were covered by water (F.M.K. JELENTÉSE 1941).

The 1940 cereal crop was generally poor as regards both quantity and quality. Of the wheat varieties, Bánkúti 1201 was the only one that tolerated the adverse circumstances. As a consequence of overabundant rainfalls the yield of barley was also poor, seldom exceeding an average yield of 1.74 tons/ha. Oats was the only cereal that made a profit (F.M.K. JELENTÉSE 1941).

The autumn soil preparation and sowing were interrupted nearly everywhere in the Mezőföld by early frosts which set in on 1st December 1940.[1]

In the spring of 1941 the thaw and the rising of underground waters, which spread over low grounds, caused great difficulties all over the Mezőföld in carrying out farm operations which were abandoned the previous autumn. The winter cereals were very poor everywhere, but those sown in spring were worse still even in the middle of May, except in the vicinity of Csákberény, Magyaralmás and Seregélyes. The Sárbogárd district was the only place where the situation was somewhat better.[2] The grain crops were still of medium quality and quantity in the summer of 1941. Only the wheat, Bánkúti 1201 in particular, showed an improvement in quality compared to the previous year, but the yield was lower. Rye too gave a poor yield; only that at Lovászpatona produced good results. Both winter and spring barley was inferior in quantity and quality. The production area of oats continued to grow due to the demands raised by the army (F.M.K. JELENTÉSE 1942).

In the autumn of 1941 the Upper Transdanubian Chamber of Agriculture again organized and financed a seed loan in the Fejér and Veszprém county districts of the Mezőföld. Loans of malting barley and oat seed were given primarily to farmers with landed properties of less than 15 ha, since they could not otherwise have obtained seed. The price of the seed had to be refunded by 1st September 1941. The wheat seed distributed was of the winter wheat varieties Bánkúti 1201, 1205 and Hatvani 5612. Large estates of over 60 ha were given genuine pure-bred seed for propagation; small farms below 60 ha received selected second-generation seed (F.M.K. JELENTÉSE 1942).

The autumn of 1941 was again unfavourable: the drought was so severe that autumn ploughing could hardly be started anywhere. Rainfalls on 1st and 12th September were of some help, however, and the winter barley and oats came up.[3] Nevertheless, soil preparation

[1] Felsődunántúli Mezőgazdasági Kamara éves helyzetjelentései 1930—1943. évekből (Annual situation reports of the U.T.C.A. 1930—1943). Veszprém megyei Levéltár (Veszprém County Archives). 78—85. sz. mikrofilm tekercsek (Microfilm rolls Nos 78—85). 83. sz. tekercs (Roll No. 83). 1938. augusztus 3-i jelentés (Report for 3rd August, 1938). (Henceforth abbreviated: F.M.K. helyzetjelentése.)

[2] F.M.K. helyzetjelentése. 18th May 1941.

[3] F.M.K. helyzetjelentése. 4th September, 4th October 1941.

and sowing only started in earnest after 10th October. In the neighbourhood of Sárkeresztes and Dunapentele sowing was completed by 25th October, and the sowing area reached the average in the previous year; but in most places the autumn sowings were poor again. In the vicinity of Seregélyes they did not even emerge, while around Kajászó the young crop suffered above-average game damage in January 1942.[4] In the spring of 1942, amidst great difficulties, the Upper Transdanubian Chamber of Agriculture organized another seed campaign. In the Mezőföld districts of Fejér county there was a great shortage of barley and oat seed. Since a large proportion of the grain crop intended for sowing purposes was fed to the animals during the winter, there was an extremely large number of claimants (F.M.K. JELENTÉSE 1942). Spring started unfavourably in 1942: on 30th March snow fell all day long in the neighbourhood of Enying, and in the snow-covered fields soil preparation and sowing came to a halt. It was only at Rácalmás that agricultural operations were able to start on 27th March. May was still so rainy and cold that work in the field was continually interrupted. As a consequence, in the region of Seregélyes the losses assumed the proportions of a catastrophe. Crops sown in the previous autumn were also very poor everywhere; around Kajászó development stopped completely. In the middle of May the farmers at Dunapentele had to re-plough the frozen, snow-packed fields.[5] As was expected, the yield of cereals was very poor again that year, and, to make things worse, in 1942 the government introduced a system of compulsory produce delivery owing to the wartime conditions. A certain amount of goods, in proportion to the registered net income of the landed property, had to be delivered to satisfy the public food supply requirements.

The drought in the autumn months of 1942 again delayed the soil preparation and sowing. Due to the protraction of the autumn work only 40—50% of the crop emerged around Küngös, Enying and Csákberény before the frosts set in.[6] The winter of 1942/43 wrought destruction with its severe cold and drought. In April 1943 the situation was catastrophic in the neighbourhood of Enying as regards the cereal crops. Around Dunapentele the winter rye and barley were again very poor. The rain which relieved the drought at the beginning of July brought some improvement; in the region of Nagylók and Rácalmás the winter cereals began to develop. However, the rain also caused problems: in several places an intensive growth of weeds started. On the night of 22nd July, the rainfall turned into devastating hail: around Dunapentele it caused a 90% loss in the oat crop and a 40—90% loss in the wheat crop, some of which had already been harvested. At Baracska 25—35% of the standing cereals was destroyed. Then, in the middle of August an eight-week period of drought began, which made the autumn soil preparation and sowing impossible again.[7] The 1943 crop year brought good yields of wheat, rye and oats, while the barley yield was fair. Because of the wartime situation there was no seed campaign in the autumn of 1943, so the seed had to be produced by the farmers themselves (F.M.K. JELENTÉSE 1944).

In consequence of the autumn drought in 1943 the autumn sowings hardly germinated; at Dunapentele, for example, the wheat emerged slowly and formed only a thin stand. In November losses were caused by mice around Csákberény, while at Enying carabic beetles destroyed the rye, winter barley and wheat stands. The autumn work did not start until after the rain had begun to fall on 14th November. In the Fejér county districts of the Mezőföld soil preparation for cereals was begun with great impetus, and it was only at Lajoskomárom that incessant rainfalls prevented work from going ahead.[8] (Owing to the military operations which swept the country in the meantime, there are no data available on the problems and results of the 1944 crop year.)

b) *Field production of row-crops between 1938 and 1944*

The summarized data of the 1935—1937 survey show that in the Fejér county districts that occupied the largest part of the Mezőföld the production of row-crops was above the national average. (Row-crops were grown on 33.2% of the arable area in the county while this figure was only 30.6% on a national scale.) The reason for this was that livestock farming (see under) also exceeded the national average in this regional unit, while the area of natural grasslands was small, making up only 9.5% of the total area of the county.

In the Mezőföld districts maize played the dominant role among the row-crops: in 1937 70,984 ha of the total arable area of 269,925 ha in the Fejér county districts was sown

[4] F.M.K. helyzetjelentése. 4th November, 4th December, 1941; 4th January 1942.
[5] F.M.K. helyzetjelentése. 4th April, 11th May 1942.
[6] F.M.K. helyzetjelentése. 8th June, 3rd October, 12th December 1942.
[7] F.M.K. helyzetjelentése. 3rd April, 7th July, 22nd August, 14th September 1943.
[8] F.M.K. helyzetjelentése. 13th October, 16th November, 14th December 1943.

to maize. In the same year potatoes were sown on 8987 ha, sugar beet on 3058 ha and fodder beet on 4873 ha.

In 1937 the following yields and yield averages were obtained for row-crops in the Fejér county districts of the Mezőföld:

grain maize:	164,590 tons,	2.31 tons/ha
potatoes:	81,320 tons,	9.054 tons/ha
sugar beet:	64,670 tons,	21.16 tons/ha
fodder beet:	111,425 tons,	22.85 tons/ha (M.S.Sz. 1938).

According to a report from the Upper Transdanubian Chamber of Agriculture, in 1938 landed properties of 60—600 ha or larger produced noticeably higher yield averages in the districts of the Mezőföld with respect to row crops, too, particularly potatoes.

In farms smaller than 60 ha in the Adony, Sárbogárd, Székesfehérvár and Vál districts the average yield of potatoes ranged between 7.82 and 8.22 tons, while on estates of 60—600 ha and larger it was 7.82 to 11.8 tons, though a yield average of 11.8 tons/ha was only achieved by a few farms above 600 ha in the Székesfehérvár and Enying districts (F.M.K. Jelentése 1939). In the case of maize such great differences between small and large estates were not found. An average yield of 1.95—2.3 tons/ha was common. The record was achieved by an estate of more than 600 ha in the Adony district, with a yield average of 3.34 tons/ha.

In a course of lectures organized in 1937—1938 by the Upper Transdanubian Chamber of Agriculture in co-operation with the Royal Hungarian Plant Production Office, a maize variety called Pettendi Aranyözön, bred in the Mezőföld, with a short vegetation period and good yield potential, was recommended to the farmers; their attention was also called to the maize variety Fleischmann Heterosis, which was undemanding highly productive and drought tolerant (F.M.K. Jelentése 1939).

The 1939 crop year was not too favourable for row-crops. Owing to rainy weather in the summer harvesting was delayed, and the maize and beet remained uncultivated. The hot dry July which followed the rain arrested the development of some row-crops, particularly that of maize. In September 1939 the threat of war led to more men being called up for military service, and due to the ensuing labour shortage hoeing was neglected in most places, so the row-crops became overgrown by weeds. As if this were not enough, storms at the end of September, especially in the vicinity of Kajászó and Rácalmás, beat down the unripe maize, in particular the late dent corn, where the ears develop high up on the stalk.[9]

Due to increasing military demands, in 1940 the area sown to row-crops increased in the Mezőföld, as it did all over the country. In spite of the destruction caused by the flower-beetle in the Rácalmás area in May (then in June in the Seregélyes and Sárkeresztúr regions, too), and the overabundant rainfall in July, which made hoeing difficult, the yield average rose. The early dent corns from Bánkút and Lovászpatona produced particularly large yields. General progress was made in the production of sugar beet and fodder beet as well (F.M.K. Jelentése 1941). Early frosts in the middle of October 1940, then rainfall starting on 26th October arrested the development of the still unripe maize in some places, e.g. at Seregélyes, Nagylók and Rácalmás. In the neighbourhood of Sárkeresztúr and Csákberény the European corn borer caused considerable damage. The increasing number of men called up and the mobilization of horses and carts hindered harvesting so much that in the Sáregres region, for example, the maize harvest had still not been completed by January 1941. Potatoes generally yielded well in the Mezőföld, though in some places, primarily in the vicinity of Csákberény, the tubers were not healthy and soon rotted.[10]

With a view to solving the up-to-date drying and storage of maize, the most important row-crop, the National Chamber of Agriculture and the Upper Transdanubian Chamber of agriculture launched a campaign for the construction of storage buildings, each with a capacity of 100 tons of maize cobs. In 1940 such buildings were erected in the Mezőföld at Kisláng, Polgárdi, Ercsi and Balatonfőkajár (capacity 100 tons each), at Dunapentele, Adony, Lepsény and Mezőszentgyörgy (200 tons), at Kápolnásnyék, Szilasbalhás and Enying (300 tons) and at Sárbogárd (500 tons). At Szilasbalhás two mobile driers were also set up(F.M.K Jelentése 1941).

In the spring of 1941 the sowing area of maize in the Mezőföld districts stagnated due to lack of sufficient seed of the early dent corn varieties Pignoletto (from Alcsút), Florentini

[9] F.M.K. helyzetjelentése. 4th June, 8th August, 5th September, 9th October 1939.

[10] F.M.K. helyzetjelentése. 10th May, 10th June, 8th July, 15th October, 16th December 1940.

and Bánkúti. The area of fodder beet increased in spite of the seed problem, as did the sugar beet area, due to the increasing demand. However, plants raised from the sugar beet seed sold by the sugar factories produced smaller roots with a lower sugar percentage (F.M.K. Jelentése 1942).

In 1941 the summer was droughty; by September the maize crop around Dunapentele, Baracs and Kajászó was almost totally destroyed. Owing to the drought, that continued even in October, the development of potatoes and beet was also arrested in most places; only the rainfall on 1st and 12th September was of some help. An early frost added to the misfortune. A large part of the beet crop was destroyed; on farms in the neighbourhood of Seregélyes some forty waggons of beet were spoilt. (The frozen beet was, however, chopped up, put into silos or clamps and pickled.) The maize crop was also damaged by frost in many places: at Küngös an almost totally undeveloped and immature maize crop (500—700 kg/ha) was harvested. In the region of Kajászó the yield average per ha was 8.7 tons for beet, 20.8 tons for potatoes and 3.1 tons for maize.[11] Owing to the serious situation the Upper Transdanubian Chamber of Agriculture was obliged to distribute relief seed-potatoes (varieties: Krüger, Ella, Gülbaba) among small farms of less than 12 ha (F.M.K. Jelentése 1942).

The maize barn construction campaign (with a government support of 6—8 pengös/m^2), initiated by the Upper Transdanubian Chamber of Agriculture in order to protect the small farmers, achieve rational stock management, ensure feed supplies and prevent price fluctuations, proved successful by the end of 1941 and the beginning of 1942: in 22 Mezőföld villages 83 maize barns had been completed. Most of them (63 maize barns in 20 villages, with a total capacity of 1965 cubic metres) were built in the Fejér county districts (F.M.K. Jelentése 1942). The fodder silo construction campaign, again urged by the Upper Transdanubian Chamber of Agriculture from 1940 onwards, was also in progress. (Farmers undertaking to establish fodder silos were given a government subsidy of 3 pengös/cubic metre each.) By the spring of 1942 fodder silos with the following capacities were completed in various districts of the Mezőföld: Mór (453.77 cu. m.), Vál (35.5 cu. m.), Székesfehérvár (512 cu. m.), Adony (289.68 cu. m.), Sárbogárd (6 cu. m.), and Enying (235.76 cu. m.). (In the Fejér county districts this involved 13 villages and 20 farmers, with a total fodder silo capacity of 1296.7 cubic metres.) The choppers required for ensiling the fodder maize were only supplied from the government subsidy for villages where more than one farmer built fodder silos. In the Mezőföld Magyaralmás was the only village to receive a chopper, as seven farmers constructed silos there (F.M.K. Jelentése 1942).

The 1942 crop year did not begin well either: on low-lying areas covered by water, owing to the cold, rainy spring months, bett could not be sown even in May. The droughty summer months were hardly compensated for by the rainfall on 27th July. In the Dunapentele region the maize, potatoes and beet developed poorly, while around Kajászó the development of fodder beet was arrested. The harvest in November therefore gave miserable results: there were very few potatoes and beets and although the maize was generally of good quality there was very little of it.[12]

The beginning of 1943 was favourable: rainfall in July started a rapid development of row crops, but also of weeds. Owing to the lack of seed potatoes the potato area remained unchanged, while the 1942 government decree resulted in an increase in the sugar-beet area. In many places the developing crop was totally destroyed by a hailstorm during the night of 22nd July, which tore the maize leaves to ribbons, thus causing a 100% loss of maize in the Dunapentele and Baracs areas. From the end of August onwards an eight-week period of drought began: the maize and potatoes became parched in almost the entire Mezőföld. At Seregélyes the drought caused 25—30% losses in the maize.[13] Thus when the potatoes were lifted in the autumn the yield proved to be poor (reports note that there was no sign of Colorado beetle in 1942 or 1943). The sugar-beet yield was also poor; the foreign varieties in particular suffered a great deal from drought. Similarly poor was the yield of fodder beet (F.M.K. Jelentése 1944).

Due to the recurrent low yields, if for no other reason, the maize barn and fodder silo campaigns continued in 1943. The construction of 23 maize barns in the Mór district, 14 in the Vál district, 62 in the Székesfehérvár district, 13 in the Adony district, 25 in the Sárbogárd district, and 50 in the Enying district of the Mezőföld was completed by that year. To accelerate the construction of fodder silos, in 1943 the Ministry of Agriculture gave the

[11] F.M.K. helyzetjelentése. 3rd August, 4th September, 4th October, 4th November, 4th December 1941.

[12] F.M.K. helyzetjelentése. 11th May, 8th August, 3rd October, 12th November 1942.

[13] F.M.K. helyzetjelentése. 7th July, 10th August, 14th September, 13th October 1943.

necessary cement completely free of charge to farms of less than 180 ha. The difficulties were increased by the fact that, owing to the wartime conditions, bricks were on the list of restricted goods and were almost impossible to purchase. In spite of this, by 1943 102 farmers in 29 villages of the Mezőföld had built fodder silos with the following capacities per district: Mór (1285 cu.m.), Vál (584 cu.m.), Székesfehérvár (829 cu.m.), Adony (685 cu.m.), Sárbogárd (35 cu.m.) and Enying (289 cu.m.) (F.M.K. JELENTÉSE 1944).

In 1943 a new governmental decree was issued ordering 2% of the arable land on farms of over 180 ha to be sown with sugar beet in order to satisfy the increasing sugar requirements. This principally affected the Adony, Sárbogárd, Székesfehérvár and Vál districts of the Mezőföld, and also the city of Székesfehérvár, but did not affect the Enying district (F.M.K. JELENTÉSE 1944). The result of the decree is unknown, since by the late autumn of 1944 military operations had reached the Mezőföld area, and most of the row-crops were trampled down by the attacking and retreating armies.

c) *Roughage production between 1938 and 1944*

According to the 1935—1937 surveys, the production of roughage in the districts of the Mezőföld (on 17.5% of the arable land) exceeded the 12.3% national average. The reason for this, as in the case of row-crops, lay in the large number of livestock in the area. Among the roughage crops the production of mixed spring vetches was dominant, though the area of lucerne, saintfoin and green maize sown thickly for use as fodder was also considerable (M.S.Sz. 1938). In spite of this a catastrophic fodder shortage recurred from year to year, putting livestock farming in a difficult position (see under). In 1938 and 1939 serious damage was caused to the roughage crops by field mice. Big landowners and small-holders were equally interested in the roughage seed campaign announced jointly by the Ministry of Agriculture and the Upper Transdanubian Chamber of Agriculture in the autumn of 1940. Six villages in the Mezőföld received 485 kg of the 28,262 tons of crimson clover seed provided by the Ministry. The seed supplies of hairy vetch were, unfortunately, announced too late, in August 1940. Due to shortage of time the farmers could not prepare the land, so only Enying, Lajoskomárom and Berhida applied for 123, 477 and 148 kg seed, respectively. The demand was highest for lucerne seed. Twenty-nine villages in the Mezőföld received 4653 tons of the 9634 tons of lucerne seed given to the Upper Transdanubian Chamber of Agriculture by the Ministry of Agriculture (F.M.K. JELENTÉSE 1941). In spite of the seed aid the roughage situation was unfavourable in summer 1940: in the course of heavy rains in July, grass which had been cut and left in the field decomposed into manure, and it turned out that the small farmers had again sown too little roughage.[14]

In the 1941 crop year the area of roughage in the Mezőföld was larger than the national average; the small farmers, in particular, grew considerable quantities of fodder crops with short vegetation periods which could be sown as a second crop (Hungarian grass, white mustard). The areas sown to lucerne, trefoil, red clover, hairy vetch and Pannonian vetch in the autumn and spring decreased because of the increased seed prices (F.M.K. JELENTÉSE 1942). At the beginning of July 1941 the first and second cuttings of lucerne, saintfoin and a mixture of oats and vetches yielded very well. However, a severe drought in August caused such a great destruction in the roughage crops, that the third cutting of lucerne gave hardly any yield. In addition, the pastures became parched by the drought.[15] Owing to the persistent shortage of fodder which threatened the existence of the livestock (see under) the Ministry of Agriculture and the Upper Transdanubian Chamber of Agriculture again organized a seed campaign in the spring of 1942. The prices of lucerne and clover were reduced, but at the same time the lucerne seed supplies were restricted, and disposed of solely through the Ministry of Agriculture. Thus, the Upper Transdanubian Chamber of Agriculture, whose authority extended over the counties of Sopron, Vas, Veszprém and Fejér, was given a total of 4.4 tons blue-labelled lucerne seed, which was distributed at a reduced price among farmers with landed properties of less than 30 ha in the spring of 1942. In addition to this, cocketted white clover and husked saintfoin seeds were similarly distributed among small farmers at a price reduced by 25% (F.M.K. JELENTÉSE 1942).

The fodder situation was bad in 1942, too. Owing to the cold, rainy spring, sowing was started late and the crop was consequently very poor. In the September drought even this poor crop became scorched, especially in the region of Rácalmás and Lovasberény.[16]

[14] F.M.K. helyzetjelentése. 8th July 1940.

[15] F.M.K. helyzetjelentése. 3rd July, 3rd August, 4th September 1941.

[16] F.M.K. helyzetjelentése. 8th June, 8th August, 3rd September, 3rd October 1942.

Due to the shortage of seed the areas of crimson and white clover, and of spring, hairy and Pannonian vetches were sharply reduced by 1943 over the entire area which came under the supervision of the Upper Transdanubian Chamber of Agriculture, including the Mezőföld. In spring 1943, due to the weather being cold and dry, the inferiority of the roughage crop was already visible in April and May. The July rains slightly improved the situation, but during the dry weather in September the roughage became parched again in many places.[17] In spite of this, the lucerne, the bird's foot trefoil (a very undemanding crop) and the saintfoin gave satisfactory yields here and there (F.M.K. JELENTÉSE 1944). In 1943 the customary seed aid did not take place. This caused particularly serious problems in roughage production. To add to the difficulties, a large area sown to perennial papilionaceous fodder plants had to be ploughed up because of damage caused by mice (F.M.K. JELENTÉSE 1944).

d) *Industrial crop production between 1938 and 1944*

According to the 1935—1937 surveys, in the districts of the Mezőföld industrial crops were only produced on 0.9% of the arable area, compared to the national average of 1.1% (M.S.Sz. 1938). To change this situation, in 1938 the National Committee on Industrial Crop Production, with the co-operation of the Upper Transdanubian Chamber of Agriculture, signed contracts with both small and large farms for industrial crop production. Hemp production was taken up in the highest proportion in the Fejér county districts of the Mezőföld. In 1939 and 1940 the production of hemp and rape was favourable, but owing to the unfavourable climatic conditions of the region oil flax and castor beans continued to produce yields below the average. In view of the wartime demand, the Upper Transdanubian Chamber of Agriculture continued to encourage the establishment of hemp processing units. In spite of the fact that construction had been in progress for years, the hemp processing unit at Sárbogárd was still not completed in 1940, on account of the unduly high estimates. The Upper Transdanubian Chamber of Agriculture nevertheless suggested building further processing units in the villages of Vál and Seregélyes. The Szeged trade inspectorate proposed organizing a training course for retting masters, but there were not enough applicants because of the increasing number of farmers called up for military service (F.M.K. JELENTÉSE 1941). Owing to the increasing demands caused by the war, the production of fibre flax, hemp and rape increased all over the Mezőföld. Since military interests were at stake, government decree No. 670—1942. M.E. made the production of oil crops compulsory. Small farmers cultivating areas of below 30 ha were obliged to grow sunflowers at the edges of the maize fields; on farms larger than 30 ha 5% of the arable area had to be sown with sunflowers or oil flax. In the Mezőföld only the Adony and Sárbogárd districts were ordered by the Upper Transdanubian Chamber of Agriculture to produce castor beans, due to the warmer climate. At the same time, the delivery prices were fixed at 500 pengős/ton for sunflowers, 750 pengős/ton for oil flax and 1000 pengős/ton for castor beans.

According to the August assessment, sunflowers yielded well in 1942. At the same time, in the neighbourhood of Seregélyes the rape was so poor that a large part of it had to be ploughed out.[18] As the military requirements increased the 1942 government decree on industrial crop production was modified. According to the new decree every farmer with an arable area of more than 10 ha was obliged to sow 7% of it to industrial crops. The compulsory production of black sesame and rubber dandelions was a novelty. Pursuant to the decree, in the Fejér county districts of the Mezőföld soybean, oil flax, rape and sunflower had to be grown on 7% of the arable land, while in the Enying district (Veszprém county) only oil flax and rape had to be grown (F.M.K. JELENTÉSE 1944). The year 1943 started badly, however. Heavy rain and hail on 22nd July caused a total loss of castor beans at Dunapentele. The dry weather in October and November, with additional damage by fleas, did great harm to the rape around Seregélyes.[19] According to the summarizing report of the Upper Transdanubian Chamber of Agriculture, the production of oil crops in the Mezőföld was a hopeless task in 1943; poor yields were obtained for soybean, too, and only the production of sunflower proved worthwhile (F.M.K. JELENTÉSE 1944).

[17] F.M.K. helyzetjelentése. 4th May, 7th July, 14th September 1943.
[18] F.M.K. helyzetjelentése. 8th August, 12th December 1942.
[19] F.M.K. helyzetjelentése. 7th July, 16th November 1943.

e) *Horticultural production between 1938 and 1944*

In the Fejér county districts of the Mezőföld, including the city of Székesfehérvár, the area of cultivated gardens was a total of 5965 ha. According to the 1935 surveys the largest proportion of the garden area belonged to dwarf-holdings (2347 ha) and small-holdings (2106 ha). Large estates grew horticultural crops on 1080 ha, and medium-sized farms on only 430 ha. In the gardens row crops were grown on the largest area, 2345 ha, which represented 49.8% of the total garden area. Besides the row crops the production of roughage crops was also considerable, taking up 20% of the gardens, a total area of 894 ha. Vegetables were grown on 21.3% of the total garden area (768 ha), legumes on 4% (127.7 ha) and industrial plants on 2.2% (133.4 ha). Due to better fertilization and irrigation, garden production provided a higher yield average than field production; the surplus in favour of the former was 77% for potatoes and 40% in the case of fodder beets (M.S.Sz. 1938).

f) *Fruit and vine growing between 1938 and 1944*

According to the 1935 survey peaches were the most profitable fruit species in the Fejér county districts of the Mezőföld; in these districts and in the city of Székesfehérvár there were 603,435 fruit-bearing peach trees, 36.2% of the total number of fruit trees. There were far fewer trees of other fruit species: 218,890 apricot trees, 142,206 freestone plum trees, 131,275 apple trees, 119,510 sour cherry trees, 101,283 pear trees, 85,422 walnut trees, 77,970 cherry trees, 62,329 almond trees, 57,607 mulberry trees, 57,437 other plum trees, 19,626 greengage trees, etc. (M.S.Sz. 1938).

The areal distribution of fruit growing was not uniform throughout the Mezőföld: the cultivation of orchards was only of real importance in the Adony (apple, apricot and peach) and Vál districts (apple, peach, apricot and walnut). In the Székesfehérvár district fruit was only grown to any considerable extent around the city of Székesfehérvár (apple, walnut), while in the Sárbogárd district there were only orchards in the neighbourhood of Sárbogárd (plums). Fruit production in the Mór and Enying districts was negligible (F.M.K. Jelentése 1942). The winter of 1939/40 caused serious damage to the fruit trees, and infection with *Epicometis hirta* in May increased the losses. Thus, the yield of apple in the autumn was very poor, 50% of the fruit rotted on the trees, and what was in storage also deteriorated.[20] The next winter (1940/41) caused further losses in the orchards. A large proportion of the plum trees perished from frost, or became seriously frost-bitten, and great damage was done to the peach and apricot trees as well. Owing to the severe cold and snow-storms rabbits attacked the apple and pear trees and destroyed whole orchards of 10—15-year-old trees. Then the high ground water level in spring 1941 caused serious damage on low-lying areas (F.M.K. Jelentése 1942).

In the autumn of 1940 the Upper Transdanubian Chamber of Agriculture suggested making agriculture more intensive. It was felt that in the case of a German victory Hungary could not think of industrialization; the employment of the surplus population was only possible through more intensive agricultural production. With this in view the Upper Transdanubian Chamber of Agriculture organized a horticultural and a viticultural-vinicultural inspectorate at Székesfehérvár, the administrative and economic centre of the Mezőföld, and assigned fruit growing managers, one to Fejér county and one to Veszprém county, which shared in the administration of the Mezőföld. At the same time local associations of fruit growers were established in the counties, under the aegis of the National Association of Fruit Producers. With a view to the better exploitation of marketing possibilities at home and abroad the National Association of Fruit Producers organized a marketing co-operative with local branches throughout the country. The desiccation units established by the Association, with the help of a government subsidy, served to make horticultural production more reliable; four of them were constructed in Fejér county. At the same time a fruit packing unit was built at Székesfehérvár by the Upper Transdanubian Chamber of Agriculture. In order to make use of fruits unsuitable for fresh consumption by processing them into fruit-brandy, the Chamber of Agriculture planned to construct storage tanks for the mash: ten at Székesfehérvár (with a capacity of 250 hl) and four at Lepsény (100 hl) (F.M.K. Jelentése 1941).

Grapevines were cultivated in almost every village of the Mezőföld; in spite of this, only 18.1% of the agricultural area (less than the national average) was covered by vineyards. According to the data of the 1935 survey, in Fejér county, which occupied most of the area of the Mezőföld, grapevines were cultivated on a total area of 7475 ha. Most of the vineyards belonged to small (3730 ha) and dwarf-holdings (3058 ha); large estates only produced grapes

[20] F.M.K. helyzetjelentése. 7th May, 15th October 1940.

on 367 hectares and medium-sized farms on 318 hectares. Of the vineyards 57.9% were established on hills (4291 ha), 20.7% (1532 ha) on immune lowland soils and 21.4% (1587 ha) on non-immune lowland soils. It should be noted that 22.7% of the vineyard area in the regional unit belonged to the wine district of Mór. (The data on vineyards do not include those in the city of Székesfehérvár.)

The distribution by variety on the vineyard area was as follows: European vines were planted on 69.9% (5181 ha), grafts with American root-stocks on 22.9% (1695.6 ha) and American vines on 7.2% (534.5 ha) of the total vine-growing area of the Mezőföld.

In 1936 the total wine production of the area was 177,407 hl: 160,523 hl of white wine, 10,885 hl of "Siller" wine and 5999 hl of red wine. Of the total wine production 29.3% (51,980.30 hl) was high quality wine, 49.2% (80,284.20 hl) common table wine and 21.5% (38,142.50 hl) was low quality wine (M.S.Sz. 1938).

The annual reports of the Upper Transdanubian Chamber of Agriculture contain hardly any information on grape and wine production. At the end of 1940 (15th October) grapes in the vicinity of Kajászó were reported to be rotten and sour, and according to the report for 8th August 1942 the vines promised a record yield.[21]

g) *Meadows and pastures between 1938 and 1944*

According to the data of the 1935 general survey, on the area belonging to Fejér county (the largest part of the Mezőföld) 5.1% of the cultivated area was meadows and 9.9% pastures (20,370 and 39,264 ha, respectively). The largest meadow area (9025 ha) was owned by the large estates, followed by the small-holdings with 7753.7 ha, and the medium-sized farms with 3491.3 ha; the total meadow area of the dwarf-holdings was 1391 ha. In the case of pastures the order was: large estates (23,479.8 ha), medium-sized farms (12,731 ha), small-holdings (3285.9 ha) and dwarf-holdings (766.9 ha).

Of the total forest area of 33,471.8 ha, the largest part (29,941 ha) belonged to large estates, while medium farms, small and dwarf-holdings owned 2771, 453.9 and 305.5 ha, respectively.

The data are for the Fejér county districts and the city of Székesfehérfár (M.S.Sz. 1938).

B) *Situation of livestock farming in the Mezőföld between 1938 and 1944*

a) *Cattle farming*

In the districts of the Mezőföld cattle farming was the most important livestock branch, exceeding the national average. According to the data of the 1935 survey, in the Fejér county districts and the city of Székesfehérvár there were 87,176 cattle. Their distribution by breed was: Hungarian Transylvanian cattle, 6642; Simmenthal, 6003; other red spotted cattle, 70,419; other western breeds, 1672; other breeds, 1917; buffalo, 523 (M.S.Sz. 1938). During the following years a gradual decrease in the number of cattle was observed; the number fell to 77,863 in 1936 and to 76,863 by 1937. (Of these, 5557 were Hungarian breeds, 66,476 were Simmenthal-Bonyháds and 2664 were other breeds; there were 628 buffaloes.) The Fejér county districts of the Mezőföld made a considerable contribution (7193 animals) to the 1937 cattle export to Italy (55 thousand animals). Exports to Germany (1788), Switzerland (312) and Austria (277) were also significant. The volume of exports was the largest for half-fattened oxen (5770 to Italy alone) and fattened oxen, of which Germany bought 1129, Italy 850 and Austria 230. Less interest was shown in slaughtered bulls (Italy bought 226, Germany 34) and in fattened cattle (Italy bought 246, Germany 24 and Austria 1). There was also little market for lean oxen (38 to Italy), cattle under two years old (71 to Italy) and lean cows (3 to Italy). In 1937 the Fejér county districts exported a total of 9570 cattle (F.M.K. Jelentése 1939).

In summer 1938 an epidemic of foot-and-mouth disease spread among the cattle at an alarming speed. Horses belonging to wandering gypsies were considered to be the main transmitters of the epidemic, and the Upper Transdanubian Chamber of Agriculture was shocked to find that fairs were nevertheless being held. The ignorance and negligence of the people was unlimited; precautions were kept at most by the large estates, while the small farmers did not observe them. According to the October report the epidemic took a mild course, though the animals became badly run down.[22] As a consequence of the epidemic Bang's disease appeared

[21] F.M.K. helyzetjelentése. 15th October 1940, 8th August 1942.
[22] F.M.K. helyzetjelentése. 3rd August 1938.

in January 1939 and caused sterility in cows, so animals yielding 4500—5000 litres milk had to be culled, for example in the neighbourhood of Seregélyes. The enthusiasm for livestock farming was deflated by the low animal and milk prices (while the production of 1 litre of milk cost 12—14 fillérs, the National Hungarian Milk Co-operative Centre paid only 11 fillérs for it). There were also increasing difficulties in feeding the animals. During the winter there was not enough roughage, and the grain fodder was both insufficient and expensive. Since the farmers obtained most of their income from livestock farming, the report from the Upper Transdanubian Chamber of Agriculture for 6th April 1939 drew a dark picture of the situation: "... for lack of money the farmers drag on the same miserable existence as in 1931—1932; even the minimum daily expenditure cannot be covered; poverty and hopelessness are assuming enormous proportions. People are exasperated, and either brood or swear. The trouble is serious and extensive."[23] The annually recurring shortage of feed made itself felt by August in 1939. Having run out of green fodder the farmers fed the cattle on hay stored for the winter. According to the report of the Upper Transdanubian Chamber of Agriculture for 9th October 1939 "... We have grave doubts about how the animals are to be fed this winter: there is very little fodder, maize or beet in the region. Some of the animals will have to be sold, probably at a loss." Owing to the low milk prices many farmers at Rácalmás stopped producing milk.[24] Most farms had great difficulty in surviving the winter of 1939/40: owing to the serious shortage of feed (hay cost 10—12 pengős/q) acute colitis, with consequent deaths, occurred among young cattle in the region of Sáregres. With the exception of a few large estates, livestock everywhere became run down. The feed supplies were so exhausted that in some places (Nagylók, Rácalmás, Sáregres) the animals were turned out to the poor grasslands at the beginning of May 1940. By June there was green fodder to improve the situation (grains and concentrates remained scarce and expensive); the prices of animals increased slightly and the price of milk rose to 20 fillérs/litre.[25] The Upper Transdanubian Chamber of Agriculture issued a warning as early as July and August: the sowing area of fodder crops was too small again, and concentrates, in particular, would again prove insufficient for the winter. The situation was especially bad in the region of Székesfehérvár and Kajászó, and the dairy farms around Seregélyes faced serious problems, as barley, red flour, oil-cake and bran were not available anywhere. In consequence of the unorganized feed supply, the winter of 1940/41 brought great difficulties again, and the problems were increased by the appearance of parasites (gastric, lung and intestinal worms, liver fluke) in several places, particularly around Seregélyes.[26] In spite of the serious problems, by 1940 the cattle stock reached the highest number since World War I: in the Fejér county districts and the city of Székesfehérvár 94,209 cattle were registered.

The Upper Transdanubian Chamber of Agriculture and the Upper Transdanubian Union of Cattle Farming Associations made further efforts to organize the supervision of the cow stock. By 1940 9.42% of the cow stock which came under the authority of the Upper Transdanubian Chamber of Agriculture was kept under supervision, compared to 5% on a national scale. This involved 298 large estates and 113 small dairy farms with 13,518 and 3419 cows, respectively. In Fejér county, to which most of the area of the Mezőföld belonged, the following numbers of cows came under supervision:

in large-estate dairy farms: 4955. Average milk production: 3307 litres; average butterfat production: 122.7 litres; average fat percentage: 3.71.

in small dairy farms: 212. Average milk production: 3165 litres; average butterfat production: 117.8 litres; average fat percentage: 3.72.

As regards milk production, the dairy farms on large estates in the area supervised by the Upper Transdanubian Chamber of Agriculture showed only a slight increase compared to the previous years, while in the small dairy farms the Fejér county districts of the Mezőföld produced the highest milk yield.

To solve the problem caused by the sterility of the cows, in 1940 the Upper Transdanubian Chamber of Agriculture organized a veterinary service for twenty larger farms, including the Count Hunyadi estate at Perkáta, the Lakatos estate at Tác, and the Frankl and Simonyi estates at Dunapentele.

In 1940 the Fejér county districts of the Mezőföld were the leading cattle exporters in the area which came under the Upper Transdanubian Chamber of Agriculture, with a total

[23] F.M.K. helyzetjelentése. 3rd February, 6th April 1939.

[24] F.M.K. helyzetjelentése. 8th August, 9th October, 16th December 1939.

[25] F.M.K. helyzetjelentése. 12th April, 10th May, 10th June 1940.

[26] F.M.K. helyzetjelentése. 12th August, 16th September, 15th October, 16th December 1940.

export of 7038 cattle. Of these, 5887 cattle were exported from large estates (4604 to Italy and 1283 to Germany) and 1151 from small farms (615 to Italy and 536 to Germany) (F.M.K. JELENTÉSE 1941).

In spite of the fact that in the winter of 1940/41 both small and large farms struggled with serious feed shortages, the livestock survived the winter in a healthy, though weakened condition. Epizootic diseases only occurred among the cattle at Seregélyes (parasites), Sáregres (intestinal worms) and Rácalmás (liver fluke). Parasites caused most damage to the young cattle. Both roughage and grain fodder were so scarce that at Seregélyes, Nagylók and Kajászó the animals were turned out to grass in the middle of May, or winter barley and rye stands were cut for fodder. At Dunapentele the maize was cut for fodder, without any consideration of the shortage of maize which would arise later as a consequence. The first and second cuttings of roughage had yielded well by July; it was only in the region of Baracs that a pressing shortage of fodder was still felt. However, the drought in September ruined everything again: the grazing lands became scorched, the roughage was poor, and by the winter months yet another serious shortage of fodder was expected.[27] The grain fodder shortage was also catastrophic again.

In spite of the continuous fluctuation in the milk prices and the critical situation of the feed supply the number of dairy farms in Fejér county increased. In 1941 the following dairy farms functioned in the districts of the county:

in large estates: 147

number of cows: 7081; average annual milk yield: 3186 litres with a butterfat content of 3.66%; 53.6% of the cows were under constant veterinary control;

small dairy farms: 24

number of cows: 1020; average annual milk yield: 3225 litres with a butterfat content of 3.74%; 3.6% of the cows were under veterinary control.

Among the dairy farms on large estates in the Mezőföld, Miklós Szávits' farm at Janicsárpuszta had an outstanding annual milk production of 4810 kg, while the best of the small cattle stocks, at Baracs and Gyuró, had average annual milk productions of 4628 and 4331 kg/cow, respectively (F.M.K. JELENTÉSE 1942).

1942 started amidst great difficulties again: according to reports from the Upper Transdanubian Chamber of Agriculture there was a pressing grain fodder and roughage shortage everywhere, but particularly in the small farms. Consequently, milk production in these farms fell to zero. In the middle of May the animals around Magyaralmás faced starvation, and the livestock on large estates in the neighbourhood of Seregélyes were in danger of destruction. On the Freud estate at Ráckeresztúr an epidemic of foot-and-mouth disease appeared in May. At the beginning of June the farmers put the animals out to graze. It was only at Dunapentele that the farmers succeeded in purchasing concentrates (oil-cake, bran). The poor roughhage and green fodder crops were again destroyed by drought, and at the beginning of August fodder was scarce in the regions of Rácalmás and Dunapentele. To add to these problems, the epidemic of foot-and-mouth disease reappeared at Enying and Nagyveleg. The fodder shortage was increased by the compulsory delivery of maize, which left hardly anything to the farms.[28]

In spite of the increasing number of silos completed by 1943, mainly in the large farms but with some in the small farms, this year was again characterized by a shortage of fodder. The threat that fodder supplies would be insufficient for the winter was felt by October 1943. In November there was hardly any fodder at Seregélyes, while at Dunapentele it was mainly the small farmers who were inadequately supplied.[29] In spite of the difficulties the Upper Transdanubian Society of Livestock Farmers made an attempt at organized and controlled cattle rearing. By 1st November 1943 188 dairy farms were under its supervision in the Fejér county districts of the Mezőföld, namely:

164 in large estates, with a total of 7889 cows (7335 Hungarian spotted, 307 full-bred Simmenthal, 65 Simmenthal and 182 badger-coloured), and 24 small dairy farms, with a total of 1487 cows (1464 Hungarian spotted and 23 full-bred Simmenthal).

The largest controlled stock of cattle was found on the Előszállás estate of Zirc Abbey, where a total of 595 Hungarian spotted cows were kept on eight farms (F.A.Sz. JELENTÉSE 1943–1944).

[27] F.M.K. helyzetjelentése. 11th March, 5th April, 18th May, 3rd July, 4th September, 4th October, 4th November, 4th December 1941.

[28] F.M.K. helyzetjelentése. 4th January, 11th May, 8th June, 8th August 1942.

[29] F.M.K. helyzetjelentése. 7th July, 14th September, 13th October, 16th November 1943.

b) *Horse breeding*

The Mezőföld was an area suitable for breeding warm-blooded horses. According to the data of the 1935 survey, in the Fejér county district and the city of Székesfehérvár there were a total of 24,796 warm-blooded horses: 274 English thoroughbred, 2437 Nonius, 1595 English halfbred, 43 Arab thoroughbred, 809 Lippizan, 413 Arab breed and 19,225 other warm-blooded horses. There were 10,592 cold-blooded horses, making up 14.4% compared to 11.2% on a national scale. Thus, in 1935 the horse stock of the Mezőföld, excluding the Enying district, numbered 35,388.

Horse breeding in the district was based on 134 stud-horses on the Székesfehérvár stud-farm (48.5% of these were English halfbreds, 29.9% Nonius and 9% Arab halfbreds) and on the nearby state-owned stud-farm at Kisbér (M.S.Sz. 1938).

The horse stock was sharply reduced by the mobilization against Czechoslovakia in the autumn of 1938 and against Romania in August 1940. However, military horse prices were not favourable for horse-breeding; a four-year-old horse raised on a private farm cost the producer 1400 pengős, while a horse of the same age raised on a stud-farm cost 2000 pengős. The army, on the other hand, paid an average price of 420 pengős for a horse (F.M.K. JELENTÉSE 1941). The recurring fodder problem left its mark on horse breeding, but a rise in buying prices after the autumn of 1941, when the war against the Soviet Union started, boosted horse breeding. The Horse Purchasing Committee of the Royal Hungarian Army bought a 4—7 year-old saddle-horse for 700—800 pengős, an artillery draught-horse for 800—900 pengős and a machine-gun pack-horse for 600—700 pengős (F.M.K. JELENTÉSE 1942).

Since horse breeding was of a lower standard than other livestock branches, in 1941 the Upper Transdanubian Chamber of Agriculture made efforts to create organized horse breeding. In 1941—1942 three districts of the Mezőföld, the Enying, Sárbogárd and Adony districts, were developed into a breeding area exclusively for English halfbreds, with 4, 6 and 4 mating stations, respectively. The Mór district (with two mating stations) was divided into two breeding areas: one for Nonius in the western part of the district, and the other for English halfbreds in the eastern part; the Vál district (with six mating stations) had a breeding area for English halfbreds in the northwest, and one for Nonius in the southeast; the north-eastern part of the Székesfehérvár district was a breeding area for Nonius, while in the largest part of the district English halfbreds were raised (there were ten mating stations in the district). Horse breeding in the six districts listed above and the registration of horses in stud-books were carried out under the direction of the Székesfehérvár stud-farm. In the Fejér county districts 938 horses were registered in stud-books in 1941 with the following qualifications: 2 as elite, 209 as classI and 727 as class II. Without exception the horses registered were all warm-blooded (F.M.K. JELENTÉSE 1942).

c) *Pig breeding*

According to the 1935 survey, 260 thousand pigs were kept in the Fejér county districts of the Mezőföld, most of them lard-type; only 13.3% were meat-type pigs (M.S.Sz. 1938) The serious fodder shortage in the winter of 1938/39 caused latent swine fever to break out around Enying. The animals were in such poor condition due to poor feeding that a severe epidemic of swine fever broke out in June, mainly in the neighbourhood of Sáregres, and this was aggrawated by the hot weather in July and August. By the beginning of August 30—60% of the pig stock at Sáregres had perished of swine fever; by October the loss was 50—70%, since few animals were inoculated because the vaccine was so expensive.[30] The winter of 1939/40 also brought a catastrophic fodder shortage, and in July 1940 swine fever and erysipelas appeared in several places (e.g. Magyaralmás, Nagyveleg, Rácalmás) among the run-down animals. The epidemic flared up on several occasions until December. According to a report from the Upper Transdanubian Chamber of Agriculture, the Kajászó estate and the farm servants carried out continuous simultaneous inoculations against swine fever in December. The small farmers did not follow this practice, obviously because of the high price of the vaccine. The Upper Transdanubian Chamber of Agriculture raised the idea that it was time to order compulsory inoculations.[31] The years of epidemics made their effect felt in the number of pigs; at the end of 1940 a total of 219,819 pigs were registered in the Fejér county districts of the Mezőföld and in the city of Székesfehérvár (F.M.K. JELENTÉSE 1941). The reduction in the pig stock was partly due to the poor maize crop in 1939, and to the fact that the official

[30] F.M.K. helyzetjelentése. 10th March, 7th June, 8th August, 9th October 1939.
[31] F.M.K. helyzetjelentése. 8th July, 16th December 1940.

buying prices fell below the cost of production. Most farms switched over from meat-type pigs to Mangalica pigs, or at least to cross-breds. Crossing was promoted by a centrally organized exchange of Mangalica boars (F.M.K. JELENTÉSE 1941). A further decrease in pig prices at the beginning of 1941 doused the farmers' enthusiasm for pig breeding. After the prices had been rationalized it turned out that there was not enough fodder. By contrast to the anarchic breeding conditions prevailing in the small farms, systematic, organized pig breeding was only practised on a few large estates in the Mezőföld. The only registered meat-type pig stocks to be found in the Mezőföld were in the Székesfehérvár (7) and Adony (3) districts. Registered Mangalica farms functioned in the following districts: Mór (3), Vál (2), Adony (7), Székesfehérvár (7), Sárbogárd (3) and Enying (3) (F.M.K. JELENTÉSE 1942).

The spring of 1942 again brought a pressing shortage of fodder; therefore, in April the farmers around Nagylók sold their young pigs at half-price. Owing to a recurrence of the fodder shortage in the autumn and winter months, the sows were slaughtered in December at many places in Dunapentele and the piglets were sold at a low price.[32] The spring of 1943 brought some improvement in the fodder situation, but then, in July, the lack of vaccine caused an epidemic of swine fever and erysipelas at Velence, Nagylók and Rácalmás, which soon spread to Seregélyes and Enying, where many 4—5 year-old sows perished although they had been simultaneously inoculated. In the late autumn months, when a severe fodder shortage occurred again and vaccine was not available either, swine fever threatened to break out again, particularly in the vicinity of Kálóz.[33] According to the unanimous opinion, 1943 was a catastrophic year for pig-breeding in the Mezőföld. The Upper Transdanubian Chamber of Agriculture pointed out that the danger of epidemics was partly caused by the primitive keeping conditions. Thus, the Chamber organized a model pigsty campaign, and although the wartime conditions involved a considerable shortage of building materials, model pigsties were built in a number of villages (Gyuró, Tabajd, Vereb) with 500 pengős of state support (F.M.K. JELENTÉSE 1944). The Upper Transdanubian Society of Livestock Farmers also stepped up its activities and brought 47 pig farms in the Fejér County districts of the Mezőföld under its control by 31st December 1943. On the 47 pig farms 1492 pigs were kept: 1347 Mangalica, 101 Yorkshire, 17 Berkshire and 27 Cornwall pigs. However, only 99 of these animals formed the property of small farmers (13 at Gyuró, 11 at Vereb, 15 at Tabajd, 45 at Adony and 15 at Baracs). Most of the supervised animals (1393) belonged to large estates. The most important supervised large-estate pig farms were: the Fejér County Sugar Factory Co. (at Göböljárás) with 97 pigs, the Belák estate (Nagydádpuszta) with 60, the Mélykút and Ménesmajor estates belonging to Zirc Abbey with 77 and 71, respectively, and the Tótfaludy estate (Líviamajor) with 62 (F.Á.Sz. JELENTÉSE 1943—1944).

d) *Sheep breeding*

According to the 1935 survey, in the Fejér county districts of the Mezőföld some 80,000 sheep were reared, more than the national average. Of these 58.5% were combing-wooled merino, 33.8% were felt-wooled merino, 1.8% were meat-type merino, and 5.9% were other breeds. In the following years the sheep stock decreased in number to 70,082 in 1936 and 69,250 by 1937 (F.M.K. JELENTÉSE 1938). After this the sheep stock remained fairly stable: in 1940 a total of 69,883 sheep were recorded in the Fejér county districts of the Mezőföld and in the city of Székesfehérvár (F.M.K. JELENTÉSE 1941). The Upper Transdanubian Chamber of Agriculture called attention to the fact that the reduction in the sheep stock was due to an ill-considered price policy and could seriously affect military interests. Since three of the seven registered sheep farms in the area administered by the Upper Transdanubian Chamber of Agriculture were to be found in the Sárbogárd district of the Mezőföld, in 1941—1942 the Chamber distributed 200 registered ewe lambs among the small farmers of the Fejér county districts at a reduced price (F.M.K. JELENTÉSE 1942). By 1943 some of the large estates switched over to producing milk and wool at the same time. The Upper Transdanubian Chamber of Agriculture continued to improve the quality: in the Fejér county districts of the Mezőföld 345 registered ewe lambs and 39 registered, full-wooled Hungarian combing merino rams more than a year old were distributed in 1943 (F.M.K. JELENTÉSE 1944). At the same time the Upper Transdanubian Society of Livestock Farmers placed the sheep flocks of several large estates in the Mezőföld under their supervision by the end of 1943. The most important of these were the Nagyvenyim estate of Zirc Abbey with 106 Cigája and 31 Württemberg sheep; the Belák estate at Nagylád with 37 Hungarian combing-wooled merino; the

[32] F.M.K. helyzetjelentése. 4th April, 12th December 1942.
[33] F.M.K. helyzetjelentése. 7th July, 16th November 1943.

Hunyadi estate at Nagylók with 26 Hungarian combing-wooled merino; the Karcag estate at Alsószentiván with 49 Hungarian combing-wooled merino; the Szluha estate at Cece with 76 Hungarian combing-wooled merino, etc. (F.Á.Sz. Jelentése 1943—1944).

C) *The struggle to modernize agriculture*

In the nineteen thirties and forties there was no balance between livestock farming and crop production in the Mezőföld either in large or small farms, though this would have benefited both branches of agriculture. Livestock farms could not produce the number of animals necessary to maintain the fertility of the soil; in the Fejér county districts of the Mezőföld there was one animal to every 2.47 ha of agricultural land (F.M.K. Jelentése 1942). The Upper Transdanubian Chamber of Agriculture held courses of lectures between 1936 and 1938 for farmers in the Mezőföld villages and elsewhere, primarily on the subject of soil conservancy. At the same time, the establishment of 140 manure depots was planned in the four counties under the supervision of the Chamber, eleven of them in the Fejér county districts (F.M.K. Jelentése 1939). From then on, the number of manure depots steadily increased; in 1939 the Chamber of Agriculture planned to establish 158. In the Mezőföld districts this movement spread slowly. By 1940 twenty manure depots were established: one each at Dunapentele, Füle, Kajászó, Lovasberény, Pátka, Pázmánd, Polgárdi, Sárkeresztúr, Sárkeszi, Százhalombatta, Vál and Székesfehérvár; two each at Csákberény and Magyaralmás, and three at Csákvár (F.M.K. Jelentése 1941). By 1941 the number of manure depots had further increased, with 11 in the Mór district, 13 in the Vál district, 3 in the Adony district, one in the Sárbogárd district and 14 in the Enying district. It could be observed that, although each farmer who built a manure depot was given a grant of 120 pengős, most small farmers did not appreciate the value of properly treated manure, and did not attach any importance to the manure depots (F.M.K. Jelentése 1942).

The other component of up-to-date agricultural production, mechanization, was in a very primitive state. Within the framework of the Farm Development Act, the Royal Hungarian Ministry of Agriculture provided a state subsidy for purchasing machinery in the summer of 1942. Tractors were sold at half-price exclusively to groups of farmers. The number of applicants was relatively high, but from the limited tractor stock only the Machine Group of Farmers at Igar and the Machine Group of the Civic Book Club at Enying were given tractors in the Mezőföld districts (F.M.K. Jelentése 1944).

One modern form of agricultural production, co-operative management, was also included in the programme of the Upper Transdanubian Chamber of Agriculture. The co-operative department of the Chamber carried out systematic work, also between 1938 and 1944, aimed at creating larger, viable economic units by organizing farming groups and co-operatives. Two "Hangya" Farmers' Groups were established in the Mór district, one with a tractor section at Csákvár, and one with a seeding section at Fehérvárcsurgó; one was established in the Vál district; six in the Székesfehérvár district, at Lovasberény, Kápolnásnyék, Sárszentmihály, Szabadbattyán, Polgárdi and Kisláng, each with a tractor section; two in the Sárbogárd district, at Sárkeresztúr and Kálóz; and two in the Enying district, at Lepsény and Mezőszentgyörgy (F.M.K. Jelentése 1944). But before co-operative farming, in a socialist rather than a capitalist form, became general, the farmers of the Mezőföld first had to survive a devastating war.

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D. Cs. Veress

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AS I SEE IT...

PRESENT AND FUTURE OF HORSE BREEDING IN HUNGARY

In past centuries Hungarian horse breeding was of an internationally high standard. Hungarian horses excelled in beauty, intelligence, hardiness and working capacity.

They were primarily saddle-horses, but proved outstandingly suitable for coach service, and for agricultural and other draught work as well, in accordance with the changing requirements of the times.

It was in transport that horses were first replaced by machines; later the army, too, replaced them. In today's highly developed societies the horse has become unneeded even in agriculture. In Hungary, however, horses are still required for draught work, especially on isolated farms and household plots, in spite of advances in mechanization.

Horse breeding has thus been gradually transferred to the fields of sport, export, tourism and entertainment. Consequently, horse breeding aims have been set so as to meet these requirements.

The storm of World War II destroyed a large part of the Hungarian horse stock. During the serious battles that took place on the country's territory horses were widely utilized for servicing the military operations. They were driven to exhaustion and many were carried off. Whole studs, and the entire stocks of some regions fell victim to the events of war. In 1944, the last year of the war, the number of horses in Hungary was 814 000.

After the end of the war the regeneration of horse breeding began immediately and progressed parallel with the restoration of the country. In 1945 there were some 328.000 horses in Hungary. The first task was to discover the whereabouts of the remnants of the dispersed breeding stock, to establish a stock of pure-bred mares, and to distribute them among the old stud-farms and the new horse breeding sites, relying to a considerable extent on horse populations which were brought back from Germany in 1946—1947 in reduced numbers, but consisting of the original animals (Bábolna, Kisbér, Mezőhegyes).

For at least two decades after the war there was a great need of the draught power of horses. The emphasis was therefore laid during this period on a quantitative increase in the

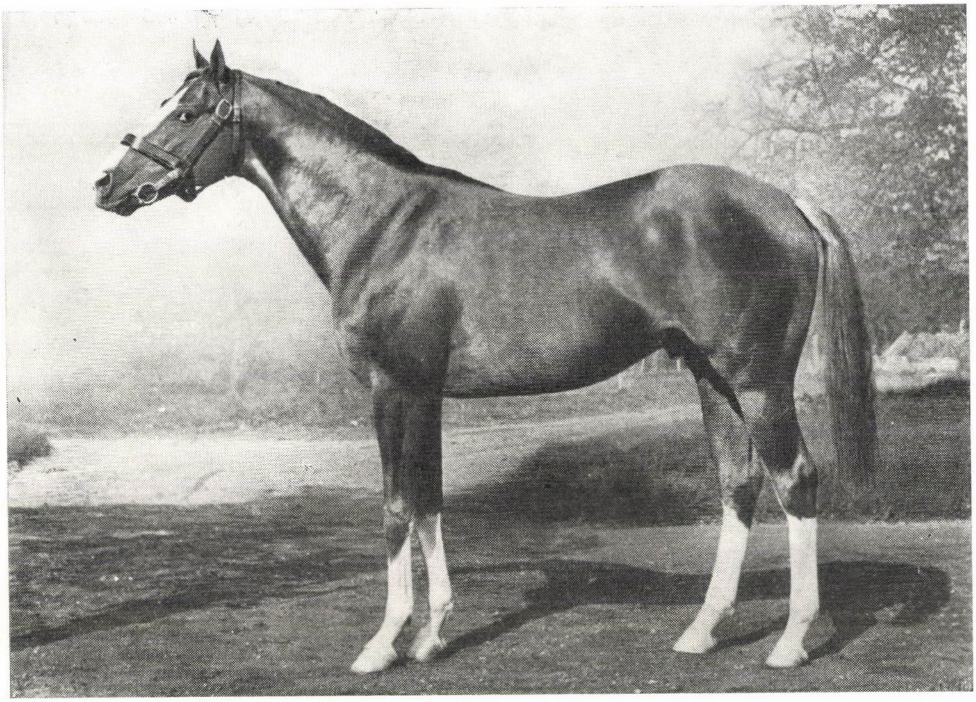

Fig. 1. Imperiál. 1960. chestnut. English thoroughbred stallion. Imi — Hurry

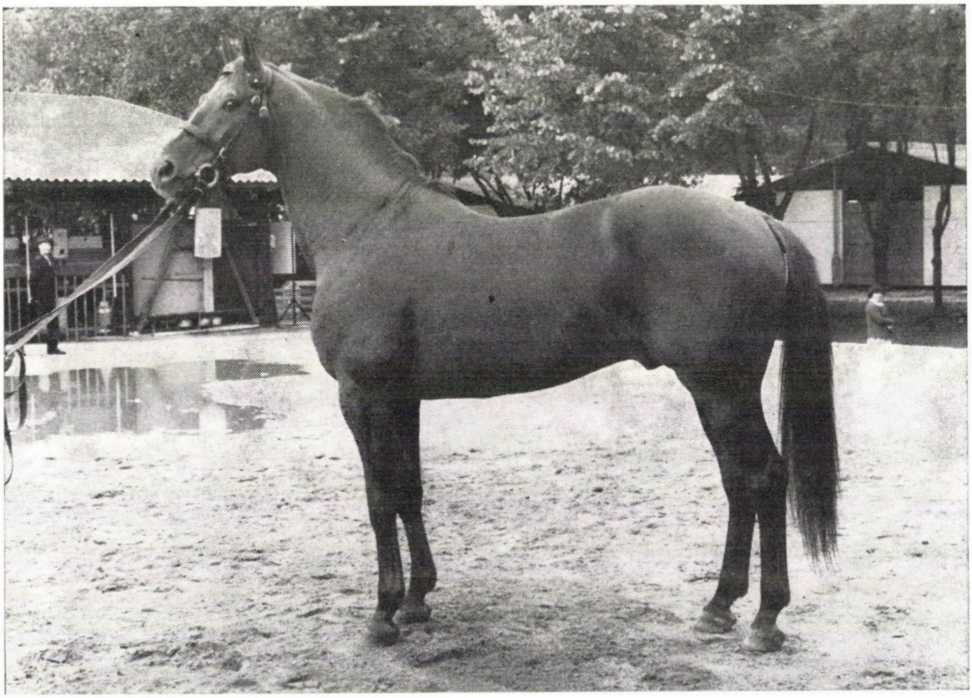

Fig. 2. 538 Maxim IX-10. 1970. chestnut Hungarian halbfred stallion. Maxim IX. 63 Széplak II.

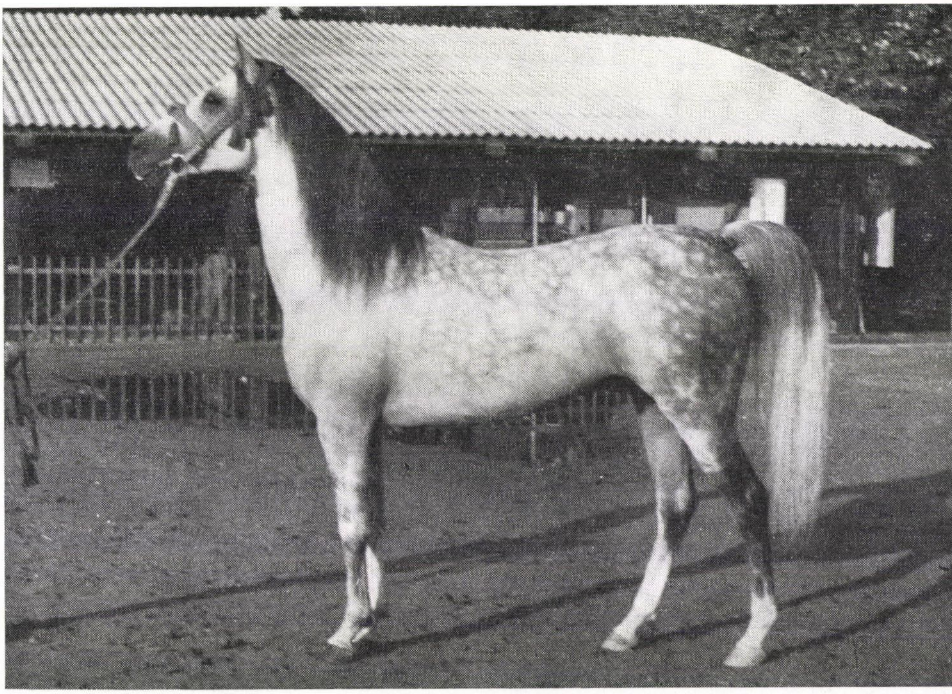

Fig. 3. Farag II. 1972. grey stallion — Arab thoroughbred. Farag original arab 25 Amurath Sahib

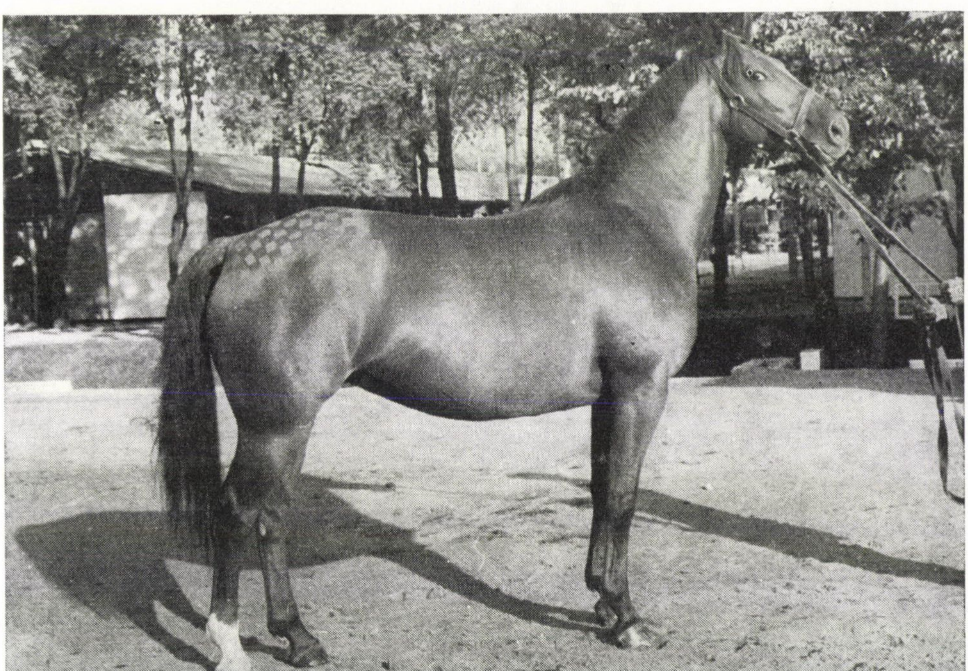

Fig. 4. 95 Széplak V. 1972. chestnut mare. Széplak V. 1891 Nimbusz II.

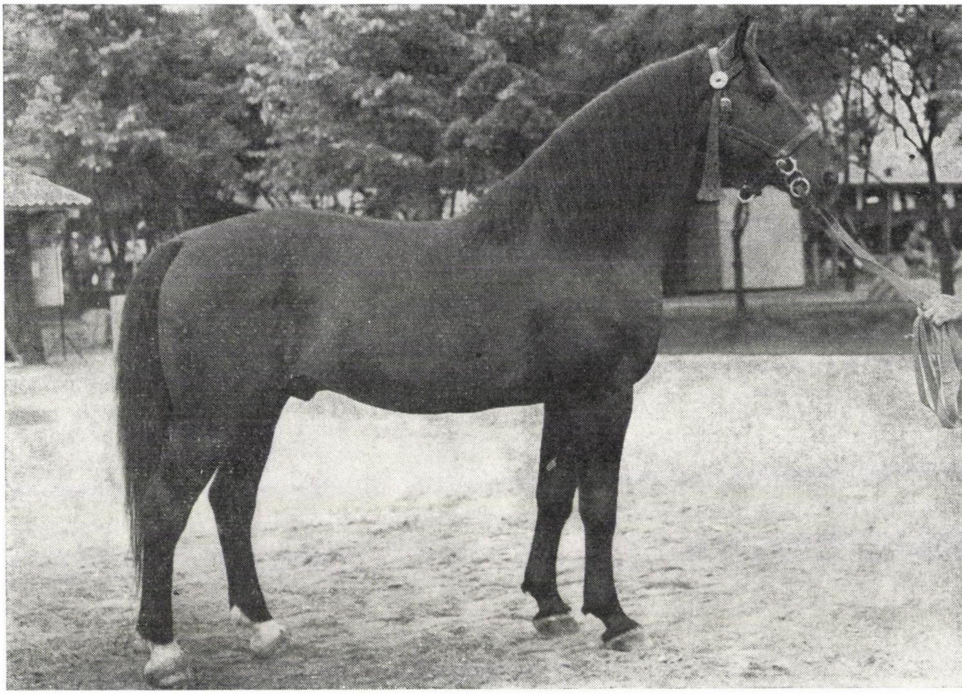

Fig. 5. Nonius IX. breed. 1972 dark bay stallion. Nonius "C" XXX. 608 Nonius "C" XI.

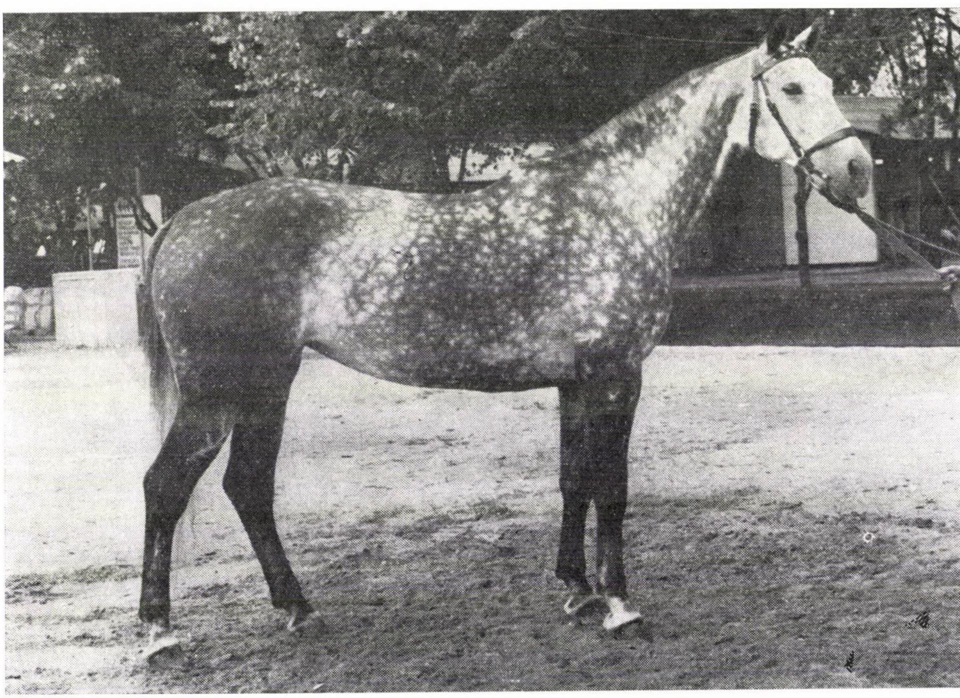

Fig. 6. Aldato-28. 1973. grey mare. Aldato, 710 Ramzes Junior. OMÉK Grand Prize winner in 1980. Sport type

stock, so that the progress of agricultural work would not be checked on account of a shortage of draught animals.

By 1958 the horse stock of Hungary already consisted of 724.000 animals. Draught horses were badly wanted in agriculture, industry and trade alike, in order to produce sufficient bread grain, to ensure the food supply for the population and to restore the production force of the country.

In the meantime the industrial revolution has made its effect felt in agriculture, too. As a consequence of the mechanization of agriculture, and due to technical progress, draught animals have lost importance on a world scale; in the developed industrial countries this category has almost disappeared.

The socialist large-scale farms now characteristic of Hungarian agriculture are highly productive and up-to-date, and here draught animals have mostly bean replaced by tractors. In a number of farms draught horses have been dispensed with, not only in field work, but also in other work processes. The horse stock of Hungary has accordingly been reduced to a great extent; by 1966 it had dropped to 294.384.

At the same time a breeding stock has systematically been developed to satisfy the demands of the originator and harnesser of the technical revolution. These demands are raised by all branches of equestrian sport and horse-racing, and also by those who ride for pleasure, as well as by the directors of colourful historical plays and films. The experience gained by the physically and mentally overwrought, either by riding or by driving, results in bodily regeneration and spiritual refreshment, so the horse acts as a force which shapes and maintains the personality.

Fig. 7. Sándor Tóth Baranyi, driver. 1973. Hungarian Driving Derby — Mezőszilas. Lippizan four-in-hand

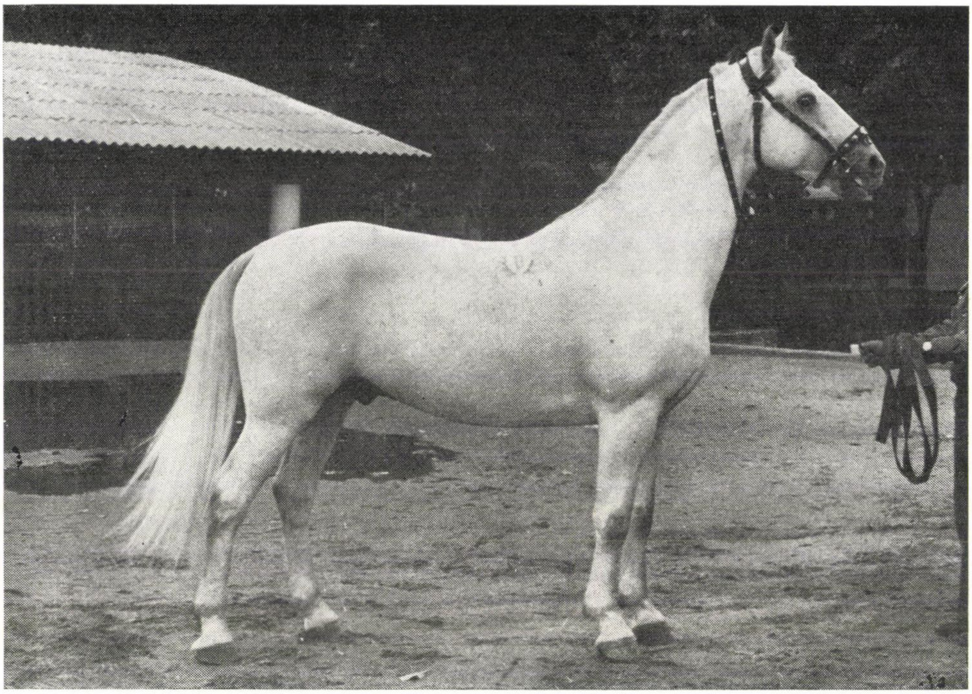

Fig. 8. 1300 Siglavy Capriola VIII-7. 1976. grey. Lippizan breed. Siglavy Capriola VIII. 31 Favory XXI.

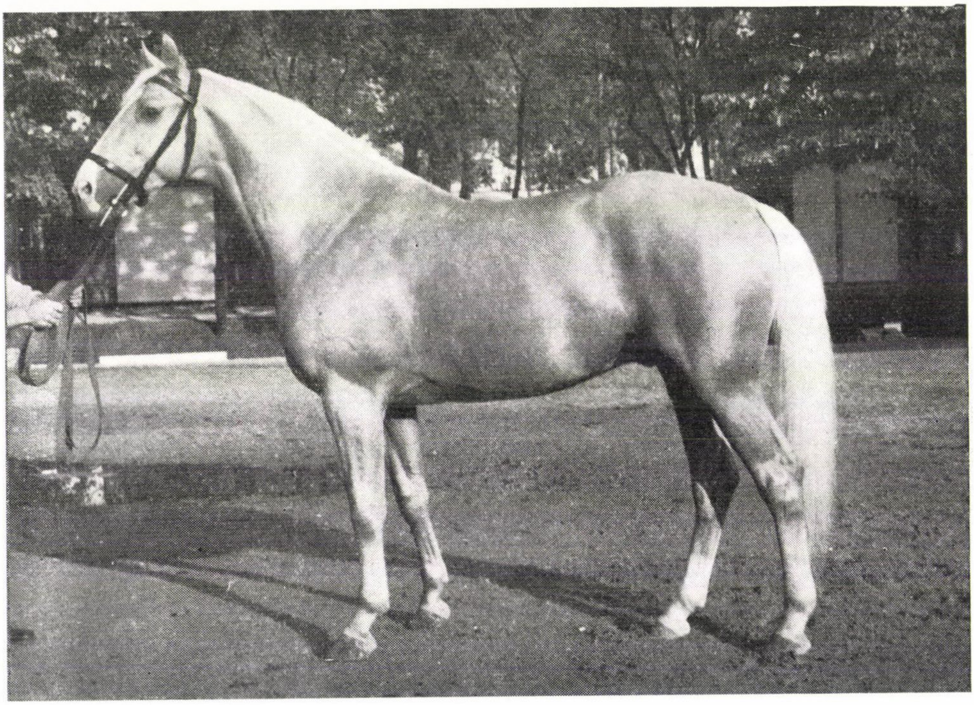

Fig. 9. 1309 Hullám-5. 1977. Isabelle stallion. Hullám, 29 Vinago

The present horse stock of Hungary totals 120.000, of which some 54.000 are mares. The number of stud-horses is 760; in recent years an annual average of 27—29 thousand mares have been mated, resulting in the birth of 12—13 thousand foals on a national scale.

Horse breeding in Hungary is managed by the National Inspectorate for Horse Breeding, which has its headquarters in Budapest. It directs breeding on state and co-operative farms and in small breeding establishments, purchases male foals from the stud-farms, distributes stallions for mating in breeding stocks and thoroughbreds and trotters for mating in race-horse stocks, classifies the mares and organizes progeny tests, is responsible for registration, and keeps the state stud-books.

The Inspectorate issues the certificates and pedigrees for all breeds, and regularly publishes the following periodicals: Tenyésztési Évkönyv (Breeding Year-Book), Magyar Méneskönyv (Hungarian Stud-Book), Magyar Ügető Méneskönyv (Hungarian Stud-Book of Trotters), Magyar Sportló Méneskönyv (Hungarian Stud-Book of Sporting Horses) and Törzsmének Könyve (Book of Stallions), thus supplying authentic data not only for domestic breeders but also for the information of foreign buyers.

The backbone of Hungarian horse-breeding is at present represented by those state farms, institutions and co-operative farms which breed the traditional sporting and race-horse breeds on a stud-farm and breeding stock scale.

The traditional Hungarian horse breeds, which have great genetic value, must definitely be maintained, as their constant improvement provides a firm basis for Hungarian horse breeding.

Mainly for this reason, and to ensure the necessary replacement of stud-horses, the Hungarian government gives considerable financial support to state and co-operative farms that maintain breeding stocks.

The breeds currently bred in Hungary are: Shagya Arab, Arab thoroughbred, Lippizan, Kisbér, Furioso, North-Star, Nonius, Gidrán, Hungarian cold-blooded, Muraközi, Hungarian sporting horse, English thoroughbred and trotting breeds. Horse breeding is now carried out on a total of 18 state farms and 27 co-operatives, with 1400 stock-mares from the breeds listed above. Including general breeding, there are 6,000 pedigree mares in Hungary; these will continue to form the basis of high quality horse-breeding in the future.

Race-horse breeding always represents the highest level of horse breeding in any country. In Hungary breeding for this purpose is also conducted in state and co-operative farms. At present 12 stud-farms, with 420 mares, are engaged in breeding English thoroughbreds. Trotter breeding takes place in 5 stud-farms, with 240 mares. The horses bred on these large farms are tested at the gallop and trotting race-courses in Budapest, where 450 horses of each type are in training every year.

Over the past 35 years thoroughbred breeding, which suffered enormous losses in World War II, has reached its prewar level, due to some successful imports and the enthusiastic work of the Hungarian experts. This has resulted in numerous victories and a prominent placing not only on the Central European race-courses, but in West German, Austrian and Soviet races, too. Although the Hungarian breeding of English thorough breds is now internationally far from the "golden age" experienced at the end of the last century (Kincsem, the wonder mare from Kisbér, winner of the Epsom Derby), which may never be recaptured, nevertheless, with Imperial, the race-horse foaled in 1960 at Kisbér, a horse was produced that scored great international successes and achieved good results even in the United States.

The Budapest Gallop Race-Course is one of the finest racing grounds in Europe. Gallop races are held weekly from March to the end of November, and twice a week in summer, on Thursdays and Sundays; altogether 54 racing days a year are organized. The races are a favourite pastime for the inhabitants of Budapest; the fresh air and the lightly wooded, grassy surroundings are in themselves a source of relaxation. The exciting races attract an ever increasing number of visitors. In 1977, the 150th anniversary of Hungarian racing, the gallop-course was given the name "Kincsem Park".

The Hungarian trotter stock is hallmarked primarily by American lines though a certain extent of French and Russian blood is also represented. Hungarian trotter breeding maintains close contacts with Soviet, West German, Austrian and Italian breeding and racing. The Hungarian Horse-Race Enterprise holds trotting races on the Kerepesi út course in Budapest throughout the year; 106 racing days are organized each year, on Wednesdays and Sundays in winter — if necessary with artificial illumination. The racers in their distinctive colours put up a magnificent performance in their two-wheeled sulkies.

Every effort is made to improve the standard of race-horse breeding; with this in view close connections have been sought and maintained with breeding and racing organizations in both socialist and western countries.

Apart from purchasing and imports, many forms of exchange and renting are employed. Close connections are maintained with English, German, Austrian, Italian, French, Soviet and American breeders and racing organizations.

Equestrian sports are gaining ground in Hungary too. No holiday is complete without jumping contests, horse-shows and driving competitions. At present 60 riding-schools and clubs function in Hungary; these are engaged in the four branches of equestrian sports: jumping, dressage, military (3-day) events and two-in-hand and four-in-hand driving.

Unfortunately, in the fields of jumping, dressage and military sport there is still room for improvement. Four-in-hand driving, on the other hand, is extremely successful. For the last eight years Hungarian drivers have regularly won the European and world championships. The names of Imre Abonyi, György Bárdos and Sándor Fülöp, four-in-hand drivers, are known all over Europe.

When speaking of equestrian sports mention should also be made of equestrian tourism, and it can safely be said that Hungary pioneered this activity in Europe after World War II. This branch of sport is becoming more and more popular; an increasing number of people — foreign visitors to Hungary — spend their holidays in the saddle, so that they can become better acquainted not only with the fine Hungarian horse stock but also with the Hungarian people and with various regions of Hungary.

With respect to horse exports, briefly, some 1200 breeding, sporting, riding and working horses are exported to various western countries each year. There is a very high demand for slaughter foals and slaughter horses; an annual average of 8000 slaughter horses and foals have recently been sold.

The Hungarians are known to be a nation of horse-lovers. I am sure this attribute is characteristic of many other nations, too, and Hungary is not the only "country of horses". Nevertheless, it cannot be denied that for Hungarians the horse is their most faithful friend.

Thus, ways of modernizing horse breeding in Hungary are sought and followed. There will be no farewell from horses and no abrogation of the contract between horse and man which has developed over nearly seven thousand years of cultural development. In Hungary the horse will never be reduced to being a "historic monument" or a decoration for picture post-cards. Though in reduced numbers and modernized form, the horse must and will remain part of Hungary.

J. PÁL
Director of the National Inspectorate
for Horse Breeding, and President of
the Hungarian Riding Society

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LECTIONES

PHYTOTRON IN THE SERVICE OF GENETICS AND WHEAT BREEDING*

1. Autumnisation as a general method for the genetic and physiological characterisation of winter habit and frost resistance

Due to the climatic conditions experienced in the Carpathian Basin, winter character and winter hardiness are fundamental components of yield stability, one of the trio of characters (yield potential, stability and quality) which are reasonably required in a wheat variety. The weather in the Carpathian Basin is very changeable, with mild winters occasionally being followed by severe ones. So there can be no doubt that the decision taken in autumn 1955 to combine genetic and physiological studies of winter habit and hardiness (RAJKI 1961) with the winter wheat breeding programme, which started from scratch but has since gone from strength to strength (RAJKI 1977), constituted a recipe for successful research in the theory and practice of wheat breeding.

Winter habit is a Mendelian character transmitted by the gametes and is associated with winter hardiness, though the latter is not exclusively a characteristic of winter wheat (winter hardy intermediate wheats also exist). The winter hardiness of winter wheat is generally most pronounced during the stage of ontogenesis when the vernalisation is not yet completed. In addition, winter hardiness depends on the state of hardening at any given time, i.e. it is considerably influenced by the environment.

A quarter of a century ago autumnisation, the study of the external and internal conditions required for the transformation of non-hardy spring wheat into hardy winter wheat, was chosen as a general method for determining the genetic and physiological characteristics of winter habit and hardiness and the conditions under which these characteristics develop. But since the possibility of autumnisation under Hungarian conditions, and in fact in general, was the subject of debate, the experimentation began with tests to show whether autumnisation existed. Naturally, considerable interest was attached, both a quarter of a century ago and today, to the fact that, if autumnisation exists at all, it is a case of the inheritance of acquired characters, a Lamarckian phenomenon, or in current jargon, genetic variability adequate to a change in the environment (RAJKI 1961, 1966, 1975; RAJKI—PÁL 1979). It was encouraging to read not long ago that STEELE (1979), who is of Australian parentage, interprets the inheritance of acquired immunological tolerance as a Lamarckian phenomenon.

2. What is autumnisation?

The starting point for the autumnisation experiments was the fact that, in the initial stage of development, spring wheat does not require a temperature around the freezing point or shortening daylength in order to flower. Ecological sowings in the autumn in consecutive generations proved, however, that the genetic constitution of spring wheat can be changed to such an extent that exposure to temperatures near the freezing point and shortening daylength are essential if flowering is to be induced, i.e. spring wheat can be autumnised. A presentation of the experimental plan and some of the results of the second of four successful

* Paper presented at the XIII International Botanical Congress in Sydney, August 27th 1981.

autumnisation cycles carried out so far in the field will provide a brief explanation of what autumnisation is.

The ecological sowings are illustrated in Fig. 1, from which the history of the treatments which will be presented here can be reconstructed. During the first, second and third years of the second cycle, spring-sown progeny tests did not indicate any change. In the fourth year of the experiment, in 1960/61, progeny tests showed that plants with total or partial winter character had developed in a variant sown in the autumn every year, which had behaved as a spring wheat in previous years.

Fig. 2 shows that in all the plants of variant SSS, which was consistently sown in the spring, heading began within a period of 11 days. By contrast, the AAA sublines, sown three times in the autumn, did not start heading until 5 days after the last of the SSS plants had headed. Only 18% of the plants from sublines of the AAA variant headed, the last of them on August 3rd for one subline and August 23rd for the other.

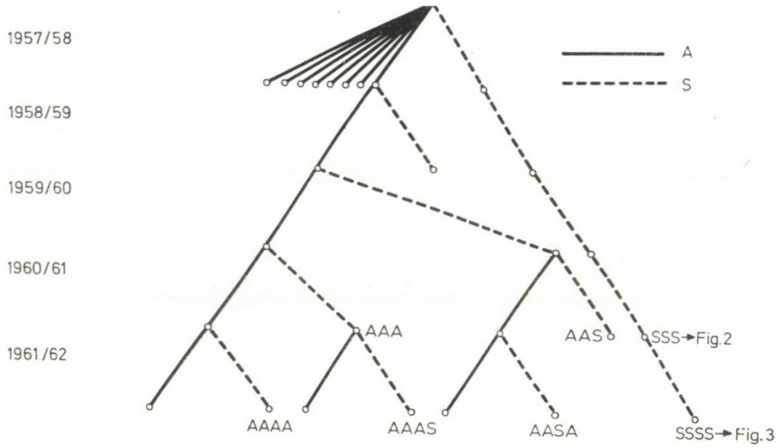


Fig. 1. Method of ecological sowings. Cycle 2

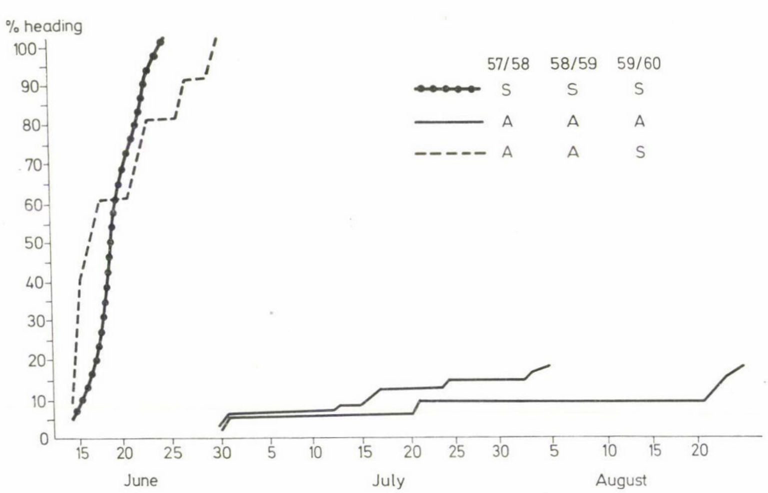


Fig. 2. Dynamics of heading. Cycle 2. 1961

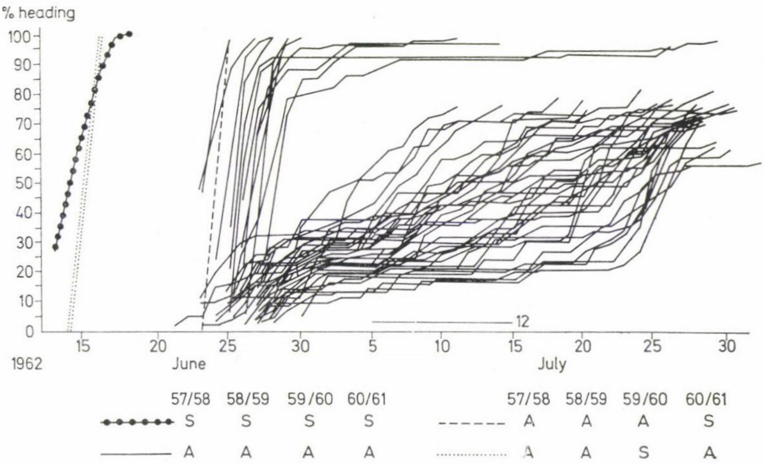


Fig. 3. Dynamics of heading. Cycle 2. 1962

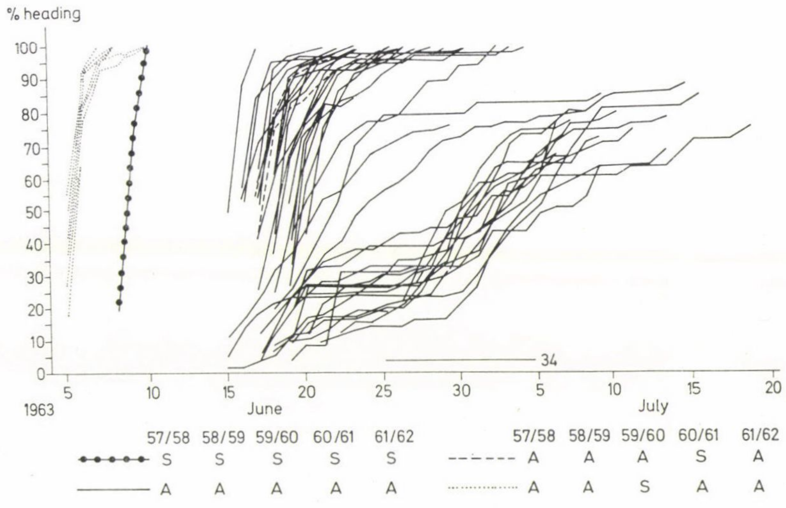


Fig. 4. Dynamics of heading. Cycle 2. 1963

Thus, the heading dynamics of the two AAA sublines indicate that this variant is no longer a spring wheat, but is not yet entirely a winter wheat. At the same time, there is very little difference between the heading dynamics of the AAS and SSS variants.

The heading dynamics of the 1961/62 sublines derived from the 1960/61 Lutescens 62 sublines described above are presented in Fig. 3. Of the 60 AAAA sublines 12 (20%) proved to have winter habit. All the plants of five AAAA sublines (8.3%) headed. Among these, even the subline which headed earliest and with an intensity similar to that of the SSSS variant headed 10 days later than the latter. The majority of the AAAA sublines (43; 71.7%) partially headed, with very variable dynamics.

The AASA sublines headed almost simultaneously with the SSSS variant. In the case of the AAAS variant, three autumn sowings were not sufficient to stabilise the winter habit, which was weakened by the subsequent spring sowing.

Table 1

Overwintering
2nd autumnisation cycle,
1962/63

Sowing variant	Overwintering, %
SSSSS	0
AAAAA	62.7
AASAA	0.9
AAASA	44.2

In 1962/63 the trend for the heading dynamics of the variants studied was similar to that in the previous year (Fig. 4).

The overwintering percentage after the extremely hard winter of 1962/63 (Table 1) was 0% for the SSSSS variant and 0.9% for the AASAA variant. Overwintering was considerably better (44.2%) in the AAASA variant. Two conclusions can be drawn from this:

2.1. Plants of the AAASA variant, which headed completely, though later than the SSSSS variant, and displayed semi-erect growth type, are winter hardy spring plants, known as intermediate wheat.

2.2. The development of winter hardiness precedes that of winter habit.

Under the circumstances the AAAAA sublines overwintered well (62.7%); in the winter of 1962/63 the Hungarian standard wheats did not survive any better. It is also interesting to note that there was no significant difference between the overwintering of AAAAA sublines with prostrate and semi-erect growth type, which indirectly supports conclusion 2.2.

Conventional and aneuploid genetic analyses, combined with multiple physiological tests (vernalisation, photoperiod, winter hardiness, chlorophyll content, assimilation temperature, organic matter accumulation, intensity of growth and cell division, enzyme activity) all confirmed that the initial stock of the Martonvásár experiments was non-hardy spring wheat, while the autumnised variants were hardy winter wheat (Rajki 1967, Rajki—Rajki 1969, 1973).

3. Half-successful experiments at reproducing autumnisation in the phytotron

At the end of the fifties, when the first cases of autumnisation were being interpreted, it was decided to study those aspects of the transformation into hardy winter wheat which were a function of the variety or of the environmental conditions (particularly the meteorological conditions) which were in turn determined by the sowing time. Several years of examination made it quite clear, however, that without modern plant raising and testing chambers the difficulties faced in determining correlations of this type were insurmountable. Only an analysis of how the different combinations of independently programmed environmental factors, which can be reproduced at will in the phytotron, are correlated with the various degrees of winter habit and frost resistance in the autumnisation plant stock will make it possible to define the environmental conditions "adequate for autumnisation".

The fact that autumnisation, as an adequate genetic variation induced by a change in the environment, could only be studied exactly under reproducible experimental conditions, was the fundamental motivation for the establishment of the Martonvásár phytotron, and consequently for the development and continual improvement of plant raising methods, unique in the history of phytotrons (Downs—Hellmers 1976), which simulate nature as closely as possible and necessary, and which have been of benefit to the whole of phytotronic experimentation.

In order to simulate nature as faithfully as possible in the climatic programmes, daily temperature rhythms appropriate to the season are used instead of the traditional stable day and night temperatures, and a daily rhythm for the duration and intensity of illumination, altering with the change of the seasons, is programmed instead of the usual photoperiods.

The climatic programmes, particularly the autumn ones (marked A for autumn plus a serial number, e.g. A24) are very diverse. The large number of autumn climatic programmes so far developed and tested includes some based on the most frequent air temperature, air humidity and illumination averages starting from the middle of September, the end of October, or the beginning of November, etc. But far more of the autumn programmes are based on the meteorological parameters of cooler but sunnier years, which occur in nature less often, and in some cases these are corrected for special experimental purposes. The faithfulness of the simulation has been checked for years by carrying out field experiments combined with parallel experiments in the phytotron, where the field conditions are simulated with a one-week delay. The only exception to the principle of simulating nature is the winter programme (W + serial number), where, except in the special frost resistance tests, temperatures around 0°C are generally programmed (Rajki 1973).

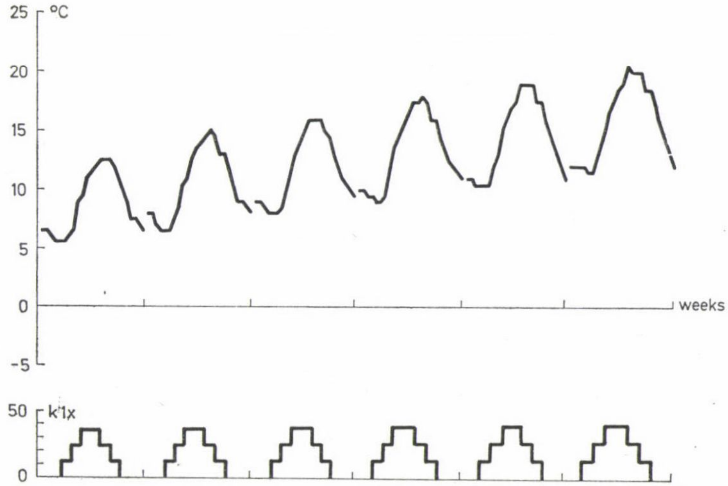


Fig. 5. Spring climatic programme for progeny testing of autumnisation generations (S1)

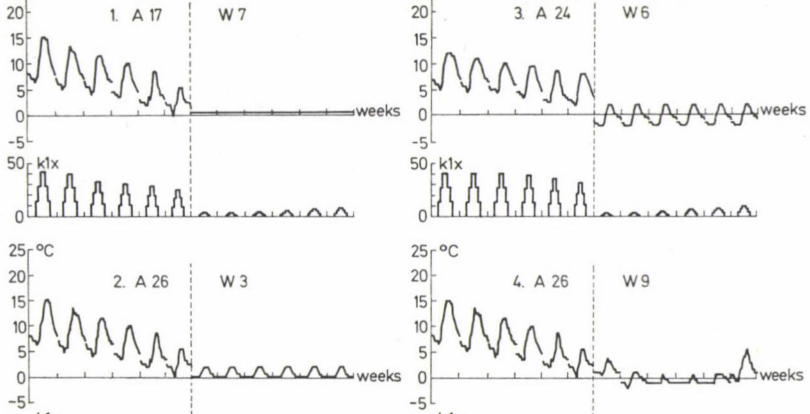


Fig. 6. "Half-successful" climatic programmes for autumnisation

The trends in air temperature, humidity and illumination values are calculated from data provided by the Martonvásár Agrometeorological Observatory (Pletser 1973) using trigonometrical curve fitting. It is assumed that the weather remains constant for seven days, and the climatic programme is changed on a specified day of the week. Phenological observations, phenometrical measurements and sampling for various analyses are generally carried out on the day the programme is changed. As an example, Fig. 5 illustrates one of the spring programmes (S + serial number) used for the spring-sown progeny testing of autumnisation generations.

Until quite recently, the repeated use of a large number of climatic programmes, elaborated after an analysis of the climatic conditions in the field during the autumnisation of classical and Mexican spring wheats, has led, reproducibly, to a maximum two-week delay in the heading of the spring wheats examined. This is quite literally a half-success, since under Hungarian conditions autumnisation can be registered if there is a delay in heading of approximately one month (Rajki—Pál 1979). One of these climatic programmes is illustrated in Fig. 6.

4. The key to reproducible autumnisation

In order to develop the climatic programmes required for reproducible autumnisation, a thorough review of the previous attempts at field and phytotron autumnisation was begun, as so often before, in order to decide why success was only partial.

The most detailed and severe criticism of the English version of the academic doctoral thesis on autumnisation (Rajki 1967) was published in "Botanicheskii Zhurnal" (Agaev 1969), but this also contained statements which implied a certain degree of recognition, as well as triggering an idea of how the half-success could be turned into full success:

"It can be seen from Rajki's experiments that the development of new forms can be directed to a large extent by the method of ecological sowings (in autumnisation experiments). If the autumn generations of spring wheat are interrupted before the appearance of intermediate forms by a single spring generation, no intermediate forms will later appear among the experimental spring wheat plants, however many generations are sown in the autumn. In an analogous manner, it is possible to prevent the process of transformation from spring to winter plants in the intermediate or semi-winter phase. Obviously, this discovery makes it possible to analyse the laws governing the development of new forms through the autumnisation process much more profoundly than before, and it is also one of the most convincing proofs of the fact that a hereditary transformation of spring plants into winter forms really occurs during the autumnisation experiments."

This refers to two variants in the second cycle of autumnisation experiments described above, both of which were sown for a number of years in the autumn. A spring sowing was included after the first two autumn sowings in the first variant and after the first three autumn sowings in the second, with the result that the first behaved as spring wheat and the second as intermediate wheat in the spring-sown progeny tests. As was seen above, in this autumnisation cycle the first autumnisation was recorded after four adequate autumn sowings, while the two variants discussed here continued to behave as spring or intermediate wheats, respectively, even after a large number of autumn sowings. However, after the 15th (16 — 1) autumn sowing for the spring variant and after the 14th (15 — 1) autumn sowing for the intermediate variant, a few progeny series which were self-pollinated and isolated and repeatedly checked with the standard tests, proved to have winter character in the spring-sown progeny tests, thus providing yet another, or rather two more, convincing proofs of experimental autumnisation.

When seeking for the causes of this phenomenon in the autumn and winter conditions during the late fifties and the sixties, it was found that the winter in 1969/70, a year or two before the stubborn spring and intermediate variants were finally autumnised, was exceptional for the large number of days with snow cover (snow depth > 1 cm). There were 92 days with snow cover in 1969/70, compared with an average of 35 days for the 12 previous winters. Beneath the snow cover there is generally a temperature of around 0°C, which is active for vernalisation, and this may favour the development of winter habit as an acquired character. The effect of various types of winter is also convincingly proved by some of the winter climatic programmes used in the phytotron, two of which are shown in Fig. 7. Here, the difference in the delay in heading in spring progeny tests was approximately two weeks, which appeared in the first generation and remained unchanged in the second and third generations, despite the fact that the two treatments only differ in the winter programme of the first generations.

It thus seemed worth comparing the number of days with snow cover in the successful field autumnisation cycles (Table 2). This shows that at least 84 days of snow cover were

Autumnisation generations and climatic programmes	Progeny testing (S1), deviation in heading compared to spring wheat ± days
1. A17+W6 2. A26+W3 3. A24+W6	-2 -2 -2
1. A17+W7 2. A26+W3 3. A24+W6	11 12 12

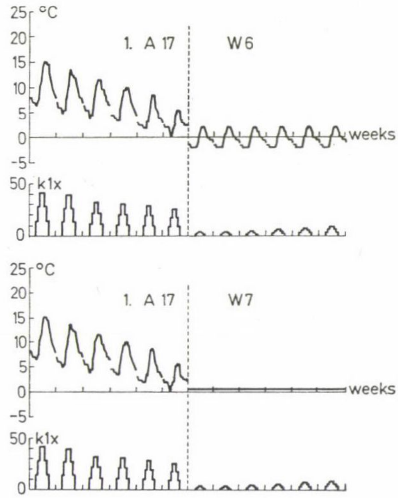


Fig. 7. Another two sets of "half successful" climatic programmes for autumnisation differing in the first generation only

needed for the first autumnisation, and this, combined with the days and hours when the temperature was around 0°C despite the lack of snow cover, represents the autumn–winter period with temperatures active for vernalisation during the second autumnisation cycle. From year to year there is a certain difference in the ratio of days with snow cover to those with no snow cover but with a temperature active for vernalisation, and this influences the light conditions, which are also important for autumnisation. This can also be seen from the

Table 2

Number of days with snow cover in successful field autumnisation cycles

Autumn—winter	1st cycle	2nd cycle	3rd cycle	4th cycle
1955/56	38			
1956/57	46			
1957/58	33	33		
1958/59		20		
1959/60		21		
1960/61		10		
1961/62			30	
1962/63			83	
...				
1969/70				92
1970'71				41
Total	117	84	113	133

fact that the 92 days with snow cover in the first winter of the fourth cycle did not prove sufficient for autumnisation, while less than this, 84 days in all, proved sufficient in the four autumn sowings of the second cycle. Two autumn sowings sufficed for autumnisation if the number of days with snow cover was 113 or 133; in fact, in one variant of this latter, fourth cycle all the experimental plants were autumnised.

5. Long winter programmes for autumnisation

But what specific implications does this have for the autumnisation climatic programmes? One advantage of the climatic programmes elaborated so far is that they allow the field vegetation period of winter wheat to be reduced to approximately half in the phytotron. And plants grown on these climatic programmes are stocky, strongly tillering plants with the growth type, culm length, straw stiffness, productive tillering and ear productivity characteristic of the variety, in other words, they are in no way deficient compared to winter wheat plants grown under optimum field conditions. The halving of the vegetation period was achieved because, understandably, the stress effects occurring in nature (temporary drought, extreme fluctuations in temperature, etc.) were not programmed in the phytotron except when it was the consequences of the stress effects which were to be studied. Naturally, this reduction in the vegetation period continues to be a great advantage in phytotronic experimentation, but since the importance for autumnisation of days with snow cover has been recognised, winter climatic programmes lasting 12 or even 18 weeks are being tested in addition to the earlier 6-week winter. Not long ago, two of these long winter treatments produced the first autumnisations in Penjamo 62.

In one of these treatments, 12- and 18-week winters were programmed for some sublines in the third generation, after two winter programmes of normal length. The 12-week winter programme did not produce anything new, but autumnisation was recorded in spring-sown progeny tests on plants raised on the 18-week winter programme (Fig. 8). After the subsequent, fourth generation, where a 6-week winter was programmed, the autumnisation was confirmed. A similar picture was found if A24 + W6 + W3 + W9 was programmed instead of A26 + W9 + W3 + W9 in the third autumnisation generation.

In the second case, 12- and 18-week winters were only programmed in the fifth autumnisation generation. Apart from the difference in the number of generations, the structure of the two autumnisation treatments only differed in the autumn programme of the first generations. The A19 programme is a modification of programme A9, so that every other week the temperature is 1—2°C lower and the illumination approximately 10% greater, but naturally

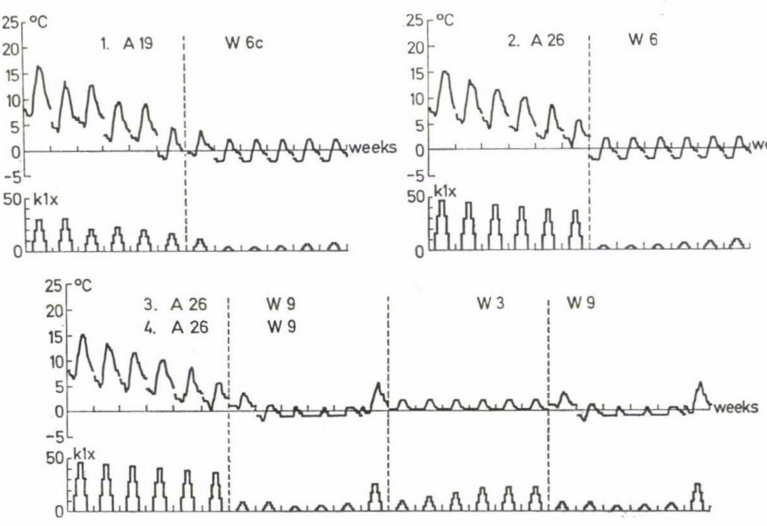
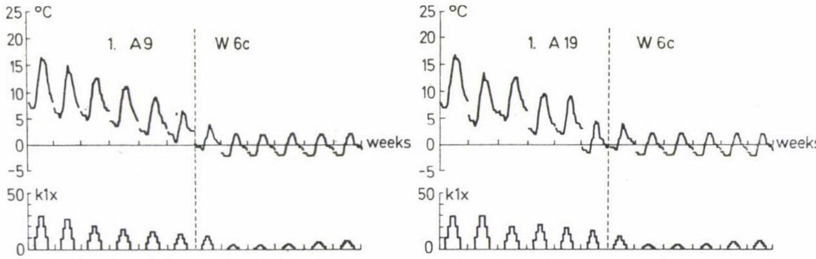


Fig. 8. Climatic programmes for one of the successful autumnisation experiments in the phytotron



Autumnisation generations and climatic programmes	Progeny testing (S1), deviation in heading compared to spring wheat, ± days
1. A9 + W6c	10
1. A19 + W6c	-3

Fig. 9. Climatic programmes for the first generations of two successful autumnisation experiments in the phytotron

these, too, simulate autumn weather conditions (Fig. 9). The seemingly insignificant difference between the A9 and the A19 programmes resulted in approximately two weeks' difference in the heading date in the spring progeny tests, but the final result was much the same (Table 3). In the spring progeny test on the fifth autumnisation generation, some of the plants did not head, i.e. they were autumnised. Using the grain yield of plants which headed in the spring progeny test, the experiments were continued in two directions: *a)* Some was used for a further progeny test in the field, which confirmed the results of the phytotron progeny test: of the 5 sublines, two did not head, i.e. they were autumnised, while the other three only partially headed, i.e. they were in the process of autumnising. *b)* At the same

Table 3

The other successful autumnisation experiment in the phytotron

Autumnisation generations and climatic programmes	No. of plants which did not head	No. of sublines which did not head	No. of plants which headed	No. of sublines which headed	Heading of plants: ± days from spring wheat	Heading of sublines: % of plants
1. A9 + W6c					10	
2. A26 + W6					6	
3. A26 + W3					4	
4. A26 + W9					2	
5. A24 + W6 + 3 + 9	2		11		17	
[SPTP]*		2		3		27— 33
[SSVS]**		11		4		54—100

* [SPTP] = Spring Progeny Test in the Phytotron, i.e. grains from the 11 plants which headed in the progeny test of the 5th autumnisation generation

** [SSVS] = Spring Sown Vernalised Seeds, i.e. grains from plants of a field propagation sown with vernalised [SPTP] seeds in spring time vernalised seedlings were sown in the field for propagation purposes. In a further spring-sown progeny test, using some of the grain yield from the propagation, 11 of the 15 sublines did not head, i.e. they were autumnised, while 4 headed only partially and/or with a delay in heading, i.e. they were in the process of autumnising.

The remainder of the grain yield obtained from the propagation, and seed from autumnisation generations which preceded the long winter treatment, were used for frost resistance testing in the phytotron. The frost test, which was developed at Martonvásár during the seventies (RAJKI 1980), can be carried out all year round, with a new test beginning every two weeks. The preliminary raising programmes, which prepare the seedlings for freezing, simulate nature and are thus an original solution. Without climatic programmes which promote normal growth and development it would be virtually impossible to reliably and consistently test the frost resistance of the experimental plants independently of annual fluctuations in the weather.* As regards the results of the phytotron test, the frost resistance of the best sublines of the autumnisation population proved no worse than that of the standard winter wheat. However, the frost resistance of autumnisation generations which preceded the long winter treatment and that of the initial spring variety, Penjamo 62, gave a value of 0 (Table 4).

6. Problems involved in the long winter programmes and possible solutions

Despite the promising results obtained in the two cases of phytotron autumnisation, new problems have also arisen. Climatic programmes with long winters are by no means ideal. While the spring wheat plants survive the 6-week winter programmes fairly well, there are difficulties in plant raising during long winters. By contrast to winter wheat, organic matter accumulation virtually ceases in spring wheat as the temperature approaches the freezing point. At the same time cell division and growth are retarded, though they do not cease completely, while tillering and the differentiation of the growing tip continue. The latter may reach stage II, III or even IV on the KUPERMAN (1953) scale during the phytotronic winter, depending on the variety. However, vernalisation is completed during stage III on the Kuperman scale, after which it is no longer possible to influence the process, since the course of a process can only be altered while it is progressing. Consequently, during the phytotronic winter, a few hours of temperatures just above the freezing point are programmed to ensure the water supply, interspersed with periods just below the freezing point in order to slow down the differentiation of the growing tip. But the winters in the phytotron are more severe than in the field, because no sooner has the temperature in the chamber sunk below zero when the soil in the pots, together with the entire root system, freezes. Above-zero temperatures cannot be programmed for more than a few hours a day, which is not sufficient to thaw out the frozen soil and root system. At the same time, to however minimal an extent, the above-ground organs of the plant are renewing their physiological activity, but the water supply from the frozen soil and root system is uncertain, causing the plants to suffer and in some cases to die. The longer the phytotronic winter, the more pronounced is the damage. Several promising solutions to this problem are now being examined, including further modifications of the climatic programmes, soil conditioning independent of the air conditioning, and the use of trickle irrigation.

7. Inhomogeneous optimation

The difficulties encountered in the course of phytotron autumnisation have stimulated theoretical research into phytotronics. One result of this is the invention of "inhomogeneous optimation", a 50% Martonvásár achievement, which was patented in the United States of America (patent no. 4 091 566) in 1978 and in Canada (patent no. 1 062 010) in 1979 (RAJKI 1979). Up till now reproducibility has been based on the homogeneity of the raising conditions. The new invention means that the research aim can be achieved more simply and rapidly, using a fraction of the experimental area, number of individuals and materials usually required, and it also opens up the possibility of optimation where it has previously seemed insoluble.

The paprika experiment shown in Figs. 10—11 was designed to test the pilot model of the invention. A regular transition in the growth and development of the plants can be observed, correlated with the step-wise variations in temperature (15—25°C) and light intensity (10,000—20,000 lux), which were programmed at right angles to each other. The effect

* A similar phytotron method for drought resistance testing is currently being elaborated.

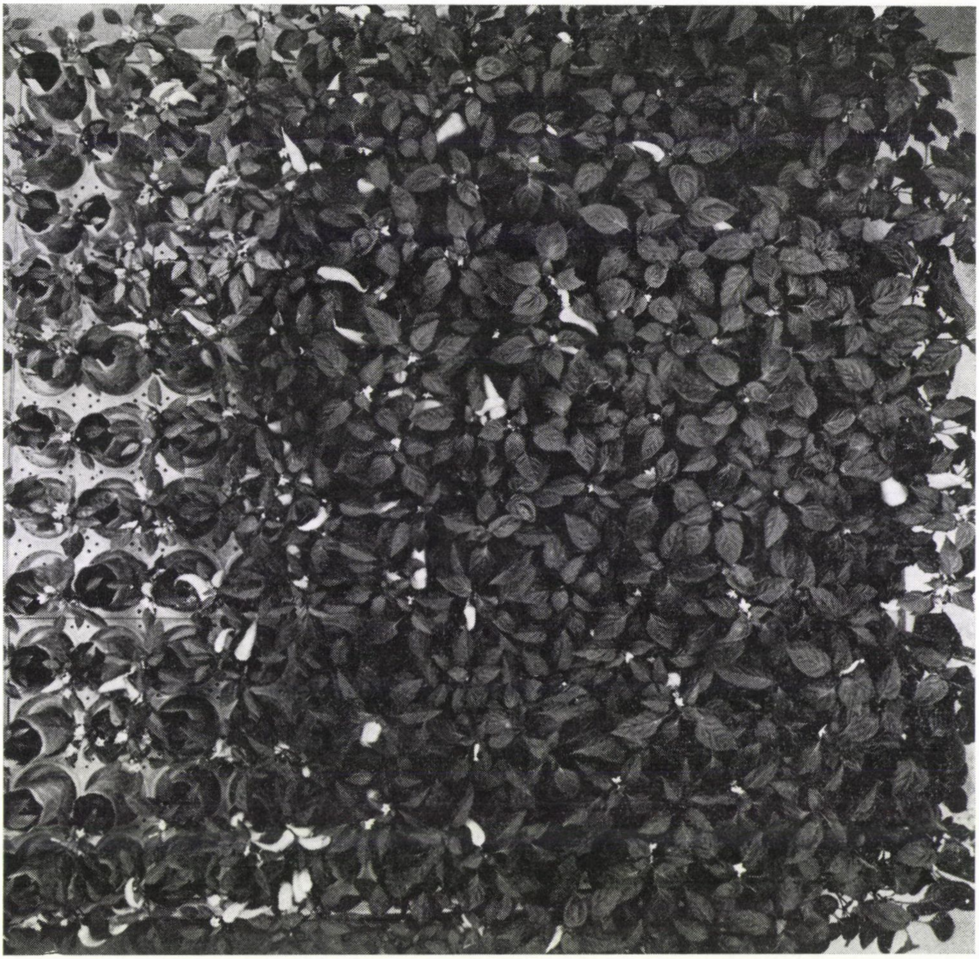


Fig. 10. Paprika plants on the inhomogeneously conditioned growth bench. The effect of the temperature gradient is very clear, while that of the perpendicular light intensity gradient iss les so

of the temperature gradient is very clear, while that of the perpendicular light intensity gradient — at least within the range programmed — is less so. A single inhomogeneously programmed chamber, with the experiment repeated once or twice for the sake of reliability, is sufficient to determine the threshold and optimum values of the temperature and light intensity for various phases in the growth and development of a paprika variety.

8. Future perspectives

This, then, was a brief account of the methodological trials and initial results achieved in the phytotronic testing of autumnisation. It is to be hoped that, in the not too distant future, this experimentation will contribute

— to making the development of autumn, winter and early spring adaptability programmable and making autumnisation reproducible in any phytotron similar in capacity to that at Martonvásár;

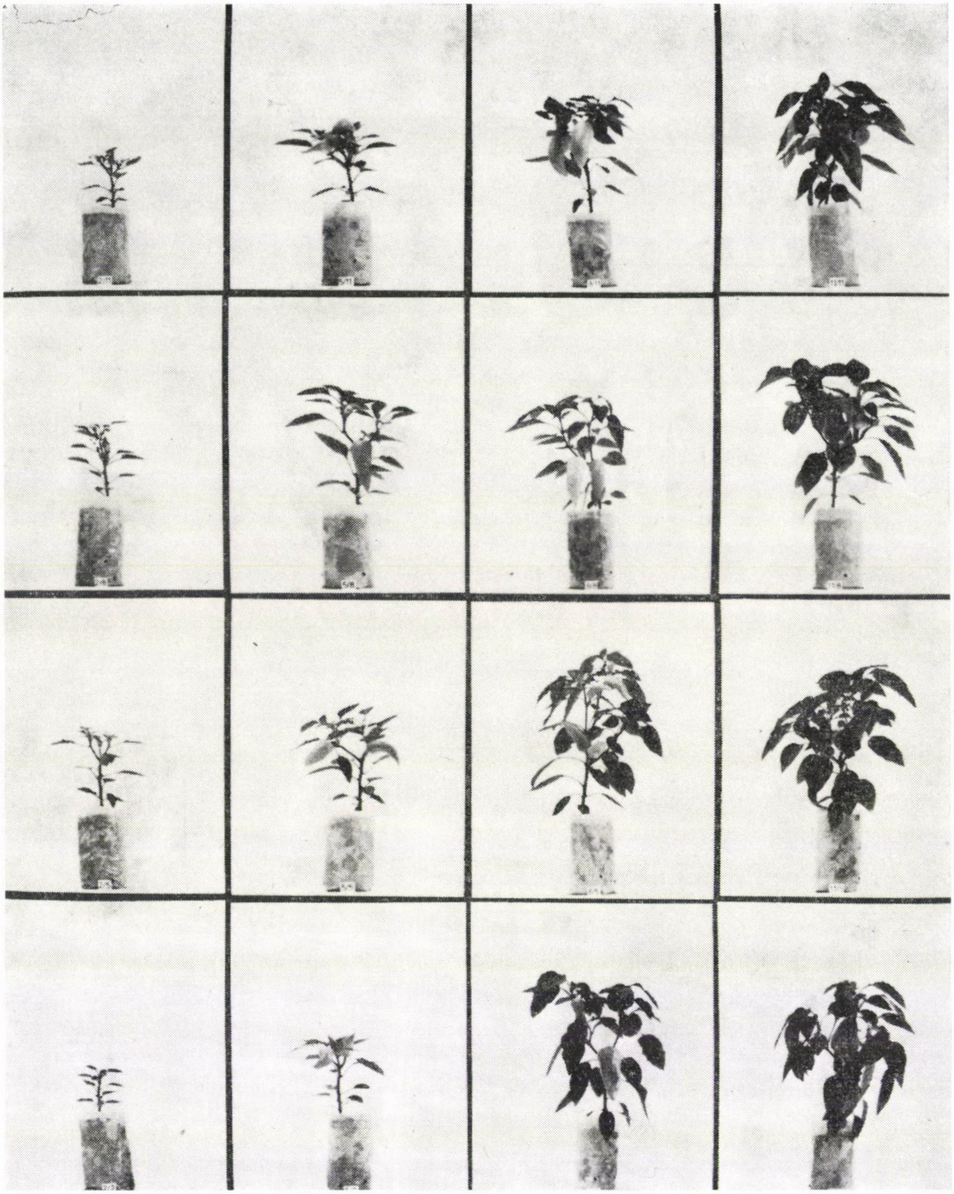


Fig. 11. Photomontage of plants 1, 4, 7 and 10, taken from along the heat and light gradients

— to freeing biology from neo-Darwinian orthodoxy (evolution only through chance variation and selection) and freeing genetics from dogmas (the continuity of the germ plasm and Crick's central dogma);
— to making Lamarckian phenomena an inherent component of Darwinian evolution and a guiding light for the genetics of the third millennium.

Table 4

% survival of autumnising and autumnised lines of the spring wheat Penjamo 62 frozen at −15°C

No.	Variants	% survival
1.	Penjamo 62	0
2.	(A9 + W6c) + (A26 + W3)	0
3.	(A9 + W6c) + (A26 + W3) + (A24 + W6)	0
4.	(A9 + W6c) + (A26 + W6) + (A26 + W3)	0
5.	(A9 + W6c) + (A26 + W6) + (A26 + W3) + (A26 + W9) + (A24 + W6 + 3 + 9)	76.3
6.	(A9 + W6c) + (A26 + W6) + (A26 + W3) + (A26 + W9) + (A24 + W6 + 3 + 9) + [SPTP]*	87.5
7.	(A9 + W6c) + (A26 + W6) + (A26 + W3) + (A26 + W9) + (A24 + W6 + 3 + 9) + [SPTP] + [SSVS]**	87.3
8.	Libellula: slightly hardy Italian winter wheat (in production in Hungary)	7.5
9.	Martonvásár 4: standard winter wheat in Hungary	79.8
10.	Mironovskaya 808: very hardy Russian winter wheat	92.5

* [SPTP] = Spring Progeny Test in the Phytotron, i.e. grains from the 11 plants which headed in the progeny test of the 5th autumnisation generation

** [SSVS] = Spring Sown Vernalised Seeds, i.e. grains from plants of a field propagation sown with vernalised [SPTP] seeds in spring

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The author wishes to express his indebtedness to all those members of the Martonvásár research team who could not be mentioned here. Thanks are also due to the organisers of the XIII International Botanical Congress for enabling the author to present this paper.

S. Rajki
Agricultural Research Institute of the
Hungarian Academy of Sciences, Martonvásár

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NUCLEAR METHODS IN ENVIRONMENTAL PROTECTION IN HUNGARY*

In the nineteen sixties environmental protection took its rightful place in most countries of Europe, including Hungary, in both public life, the economic world and in the field of scientific research.

* Paper presented at the XI ESNA Congress in Debrecen on August 24—30th 1980.

A comprehensive act dealing with the protection of the human environment was passed in Hungary in 1976. This aimed to set down all the basic conventions and rules which are connected with the protection, conservation and planned transformation of the human environment, in order to ensure the protection of human health and a continuous improvement in living conditions for both the present and future generations. This act expressed clearly that the protection of the human environment is the duty and interest of the whole society, and further, that all citizens are entitled to live in an environment worthy of Man.

The implementation of environmental protection, as is well known, requires considerable financial means. According to the conception of the Hungarian environmental policy the different objectives will have to be realized step by step, as foreseen by the national economic plan and in order of social importance, proportionately with the development and resources available from the national economy. Priority must be given to objectives which have a positive influence on the quality of human life and health. The realization of environmental protection objectives has to be promoted by the intensive development of science and technology, the careful organisation of scientific research, the practical application of domestic and international scientific results and the thorough education and training of specialists in this field. Provisions have been made at various levels of education and through the public information media to inform Hungarian citizens of the aims and requirements of environmental protection. The civilian population also contributes to national environmental protection with voluntary work.

In order to protect the human environment, the Hungarian People's Republic has put the soil, water, air, living beings, landscape and the surroundings of communities under protection.

Biological, chemical and radiating materials can only be produced, stored, transported, handled and applied or used in irradiation work under conditions where human life or elements of the protected environment are not endangered either by a single treatment or by an accumulation of these materials.

In 1977 the Hungarian Government established the National Council for Environmental Protection and Nature Conservation which constitutes a coordinating, consultative and supervisory body of the Council of Ministers in questions of environmental protection. To carry out these measures the National Authority for Environmental Protection and Nature Conservation was founded. Special governmental regulations control the special tasks of individual Ministries in directing and coordinating environmental protection. It has been decided that all measures connected with the control and neutralization of waste materials dangerous to human health or the environment (i.e. poisonous or infectious materials) are the domain of the president of the National Authority for Environmental Protection and Nature Conservation, in coordination with the Minister of Health, while the establishment of tolerance limits for chemical, physical and biological pollutants and the study of the dangers and hazards they exert on human health come into the sphere of the Ministry of Health.

Agriculture and food production plays an important role in the economic life of Hungary. The natural potentialities of the country are favourable for crop production, for growing fruit and grapes and, in some areas, also for the production of horticultural crops. The fodder basis for animal husbandry is provided by domestically grown cereals and maize. The annual average yield of grain crops (wheat, barley, oats and maize in total) has reached 1.1—1.2 metric tons per capita and the meat production (beef, pork and poultry in total) has reached 130 kilograms per capita, thus placing Hungary in the group of leading European countries. Agriculture and food industry make up 17% of the national income, 25% of the total exports and 33% of exports sold for convertible currency. The long-range Hungarian economic policy foresees further yield increases in agriculture in the course of the next 15—20 years. As a social objective, a three-fold increase in the export commodity reserves has been set by the Government; if this becomes reality, however, the impact of increasing production on the environment must also be considered, thus rendering all new technologies which counteract negative developments even more important.

The control of the unwanted multiplication of microorganisms constitutes a special field of environmental protection. This occurs mainly in cases when easily decomposing organic material accumulates in large quantities in a relatively small space. This situation may develop in cases of communal sewage, in large concentrated livestock farms and occasionally during the accelerated eutrophisation of shallow lakes. The cleanness and quality of the drinking water is one of the most important basic human needs; very rigorous public health norms control the qualitative and quantitative characteristics of the microflora tolerated in the drinking water.

Many methods are known for the control of microorganisms; biological and chemical means have been known and used for a long time. From among the physical methods the idea of using irradiation techniques goes back some decades. Nuclear methods have been used in Hungary in the solution of environmental problems since the early seventies. A host of experiences and experimental data has been compiled, which will make the practical use of these methods possible on a larger scale in the coming decade.

Another very important field of use for nuclear methods in environmental protection is the application of different isotopes to demonstrate the movement of elements, compounds and metabolites; a better knowledge of basic processes has helped in evolving the best alternatives for protection.

In many sections of the present Conference, especially in the sections on Waste Irradiation and Environmental Pollution, detailed information on this field of research will be presented by my Hungarian colleagues; so here I will just summarize briefly some important fields.

In Hungary there are nearly a thousand smaller communities in which the supply of high-grade drinking water presents grave problems. Among the causes of this the nitrate pollution of the subsoil water and microbial pollution may be mentioned. It is of utmost importance for infants and children under 3 years to be supplied with high quality drinking water, which has to be transported to the spot in appropriate containers. This type of drinking water must be free of any pathogens and according to the specifications the presence and number of other bacteria is also very restricted. Drinking water to be stored or used at a later time must be sterilized according to the standard of quality.

Zsuzsanna Deák and Mihály Kádár carried out experiments on the sterilization of drinking water by using gamma irradiation. Based on studies with gamma irradiation water samples it has been concluded that irradiation was effective, as acceptable microbial normatives were attained. The effectiveness of sterilization amounted to 99.9% from the point of view of the survival and subsequent multiplication of microorganisms.

The gamma irradiation of sludge has been studied intensively by Hungarian research workers. Gyula Varga, György Bánki, Márta di Gléria and László Némedi studied the decrease in the bacterial count in gamma-irradiated sewage and sludge samples. It has been established that, with respect to the parameters of radiation sensitivity, a dose of 300 krad proved to be sufficient to produce a decrease of four orders of magnitude. In the case of irradiation-resistant types, however, a dosage of at least 1 Mrad was needed to achieve a decrease of four orders of magnitude. The authors recommended that prior to the irradiation of sewage and sludges the dosage needed for a decrease of four orders of magnitude should be previously established by a detailed bacteriological study.

Hungarian research workers have also carried out parasitological studies on sludge samples and investigated the possibility of gamma sterilization on two parasites which are epidemiologically important and which are distributed primarily by sewage waters. These two organisms were the cysts of *Entamoeba histolytica* and the eggs of the worm *Ascaris lumbricoides*. The irradiation dose differed in the experimental variations; in the case of *Entamoeba histolytica* 200 krad was sufficient for a completely lethal effect. With the same dose (200 krad) only 1% of the *Ascaris lumbricoides* eggs developed into larvae, so in practice a dosage of 200 krad proved to be sufficient to reduce both parasites to an acceptable, subpathogenic level.

In the course of large-scale pig breeding very large amounts of sewage (i.e. liquid manure) are produced. The sewage causes serious environmental problems in the surroundings of large-scale livestock farms, especially if it moves into water reservoirs or lakes via the ground water or streams. If absorbed by the soil, the sewage is neutralized and the nutrients contained may be taken up by crop plants. The sewage can also be used, with constant rigorous control and supervision, in the irrigation of cultivated plants; in some regions, however, the structure of crop rotation does not permit sewage irrigation or limits the use of sewage to a very short period.

For the disinfection of sewage many methods are available, such as prolonged storage, compost-making, chemical treatment and also irradiation.

Gyula Szemerédi and József Simon studied the irradiation sensitivity of bacteria frequently known to cause diseases in pigs and of those with facultative pathogenic character; the experiments were carried out with different radiation dosages from a cobalt source. The irradiation sensitivity of the different species was usually about 100 krad. The *Staphylococcus* and *Streptococcus* species showed higher resistance, as they were only destroyed by a dosage of 700 krad. The saprophytic and pathogenic mycobacteria and the spore-forming *Clostridium perfingens* also exhibited high tolerance, as these were only killed in the nutrient medium by a dosage of 1000—1500 krad.

In agreement with the international literature, the Hungarian research workers also established that gamma rays are useful in sterilizing sewage originating from pig farms. These studies contributed to the development of practical methods, which will very likely gain importance in the future.

The critical labour situation in animal breeding and farm management may also result in the introduction of physical methods, as it becomes increasingly difficult to obtain man-power for the handling (e.g. compost-making) of sewage.

From among the nuclear methods the use of high-performance electron accelerators has opened up new perspectives in agricultural research, in the quality control of the produce and also in environmental protection. High-energy electrons are obtained either from radioactive isotopes with beta emission or from accelerators. Accelerators have the advantage that the electron energy and the beam intensity can be modified easily and over a broad range.

Yet another advantage of accelerators is that the equipment produces radiation only in the "switched-on" position and that there is no need to regularly replace a decaying radioactive charge.

The use of radiation techniques presents many advantages in the treatment of wastes and sewage. By evaluating numerous foreign and Hungarian experimental data, the authors József Simon, Mária Di Gléria and Ervin Klapfer summarized the advantages as follows:

— the corrosion of the implements is much lower;

— the formation of stench and air pollution is decreased by irradiation to a minimal level and may even by eliminated;

— the speed of deposition of the solid phase and of mechanical dehydration increases considerably;

— the method is very easily applied, needing only a few personnel;

— the procedure is continuous;

— the energy consumption is about 50 times lower than with heat-pasteurization;

— the free radicals produced during the procedure and during the decomposition of organic materials start auto-oxidative processes which create higher sterilization effects; the number of pathogenic bacteria is decreased by at least 7 orders of magnitude;

— whereas in heat treatments the sludge expands greatly, so that the costs of storage and transportation also become higher, with irradiation this disadvantage does not occur;

— a substantial part of the organic nitrogen in sewage becomes transformed into inorganic nitrogen, which is more easily taken up by crop plants;

— radiation decomposes various chemical compounds, such as cyanides, phenols, some pesticides and detergents;

— the weed seeds contained in the sewage lose their germinating capacity due to irradiation and thus become harmless to crop production.

At the same time, however, the higher investments and the cost of safety appliances to protect the handling personnel also have to be considered.

At present, no electron accelerators operate in Hungary for the disinfection of sewages of agricultural, industrial or communal origin. However, a study plan has been accepted for purchasing and installing an "Integrál T" electron accelerator. According to the calculations, an irradiation dosage of 4 krad is sufficient to destroy the infectious microorganisms contained in the aqueous phase of pig manure, thus rendering the disinfected sewage directly applicable in crop production. During epidemics the presence of more radioresistant microorganisms makes a higher irradiation dose necessary to exert the lethal effect required; the "Integrál T" equipment will also be able to cope with this problem, however, since it has a maximum output of 1000 krad. The radiation capacity of the planned installation will, with a dose of 400 krad, continuously solve the disinfection problems of the sewage produced on a large pig farm with 50 thousand animals.

It is to be hoped that within a few years Hungarian researchers will be in the position to report not only on plans but also on positive experiences regarding the use of electron accelerators in environmental protection.

In connection with environmental studies, other research methods using radioactive materials have been widely used in Hungary for many years.

In the Isotope Institute of the Hungarian Academy of Sciences researchers dealt with the measurement of the tritium concentration in the environment for some years. This study was aimed at establishing the present background level of tritium in the surroundings of the first nuclear reactor unit in Hungary, which is still under construction (in Paks, south of Budapest, near the River Danube). These studies were necessary in order to be able to detect any eventual changes in the tritium level of the Danube, subterranean waters, precipitation, plants and other samples, after the reactor has started.

Research workers at the Isotope Institute, Mária Szilágyi, and I. Pavlicsek worked out a method suitable for determining the tritium concentrations of both surface and subterranean waters. The method is based on the electronic enrichment of the water samples, followed by liquid scintillation counting. Within the framework of a two-year measurement programme the authors established the background level of tritium in the surroundings of the Paks nuclear reactor.

Other research workers at the Isotope Institute, L. Horváth, Á. Pulay, and T. Froster have participated since 1977 in the Joint FAO/IAEA Division of Atomic Energy in Food and Agriculture Coordinated Programme on isotope-tracer-aided research and monitoring of agricultural residue biological interactions in aquatic ecosystems.

In the course of this research project a monitoring programme has been carried out on water samples taken from a branch of the Danube; this method consists of a radiometric variety of the method, based on enzyme inhibition, used in the determination of organophosphate and carbamate insecticide residues. The metabolic decomposition of different pesticides in an aqueous medium was followed with this method and on pesticides positionally labelled with ^{14}C and ^{3}H isotopes. The metabolism of pesticides in plants is also studied by using these labelled compounds. The knowledge of chemical changes in pesticide molecules is of utmost importance if the possible hazards of residues are to be estimated. Mention should also be made of the studies carried out by V. Friedrich and P. Pavlik, also from the Isotope Institute, who investigated the movement of isotopes in the soil. Based on their results the speed of translocation and concentration of a radioactive pollutant can be predicted in the case of a possible leak in the storage of radioactive wastes; these characteristics proved to depend largely on the soil type.

Radioactive isotopes have also been used in establishing the changes in aquatic ecosystems. A very successful example of this is the study made by Sándor Herodek, who estimated the speed of eutrophization in Lake Balaton. As is well known, Hungary has no sea coast and the largest lake, the Balaton, measures about 600 square kilometres. One of the basic characteristics of this lake is that its basin is shallow, with an average water depth of 3 metres, the deepest point being only 11 metres deep. Due to the shallowness, the water warms up very fast in the spring and presents optimal conditions for the mass growth of algae and water weeds. The lake is surrounded by intensively treated agricultural lands where the amount of fertilizers applied reaches 300 kilogram active agent per hectare; ten years ago only one quarter of this quantity was used. As the number of tourists and holidaymakers visiting the lake has also more than doubled during the past ten years, the lake receives substantially more nitrogen and phosphorus than previously.

S. Herodek determined the photosynthetic activity of the algae by using the ^{14}C isotope; the results gained for many consecutive years indicated a significant speeding-up in the eutrophization process. The studies also yielded topographic data, showing those regions of the lake which are especially endangered by the progress of eutrophization. By using these data ecological models have been prepared to predict the course of eutrophization and to give a scientific basis for a rational prevention system.

Here only a few examples have been given of the main directions in which Hungarian researchers are using radiation techniques and radioactive isotopes in environmental protection research. This short enumeration could not by any means include all the studies at present in progress, but is limited to just a few. In the sessions of the different working groups, however, these studies will be dealt with in more detail.

Nuclear methods are used to an ever greater extent in agriculture, food production and, more recently, also in environmental protection. The extent of application has greatly surpassed the sphere of experimentation and has become an integral part of everyday practice. Scientific research, however, must continue to keep ahead of practice, in looking for new methods and for possibilities of improving the present ones.

The European Society of Nuclear Methods encourages and promotes both research and its practical application. By doing so, the Society contributes significantly to the social aim of all European countries to produce more and better food for the population and, at the same time, to preserve the human environment in a healthy, enjoyable state.

I. Láng
Hungarian Academy of Sciences
1051 Budapest
Roosevelt tér 9.

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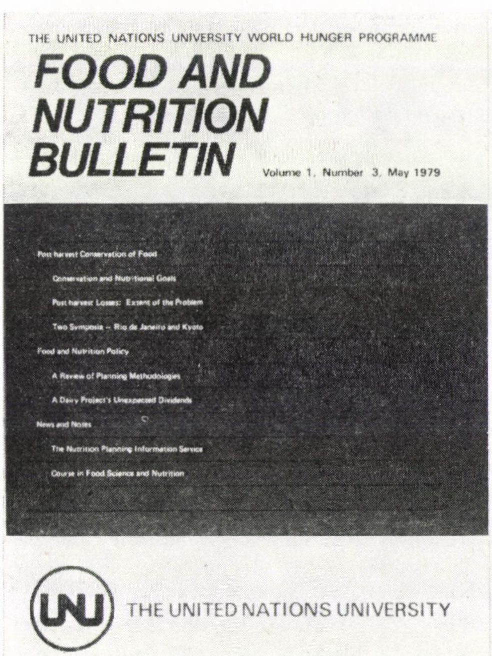
RECENSIONES

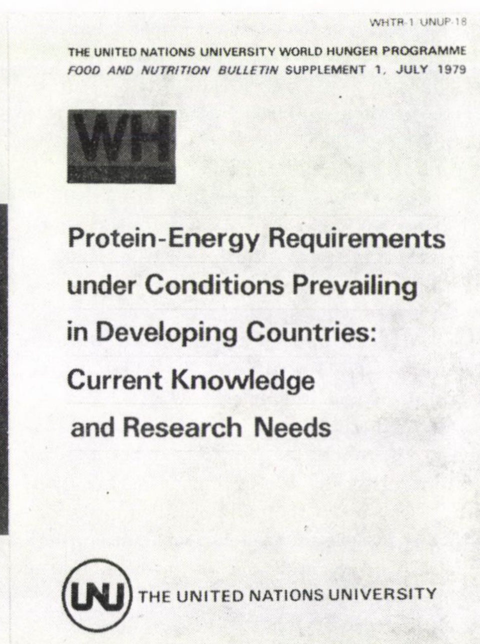
Food and Nutrition Bulletin, Volume 1, Number 3, May 1979, and Protein-energy requirements under conditions prevailing in developing countries: current knowledge and research needs, The United Nations University

Volume 1, Number 3 of the "Food and Nutrition Bulletin" published in May 1979 by the United Nations University contains many interesting articles.

The Food and Nutrition Bulletin is a forum for the publication of multidisciplinery research relevant to the "World Hunger Programme" of the United Nations University, which deals with the most diversified aspects of lessening hunger and malnutrition in the world.

This issue presents three papers on the subject "Food and Nutrition Policy", followed by the manuscripts of five interesting lectures delivered at two international con-





ferences held on post-harvest food conservation. The rest of the magazine contains various publications of an informative nature connected with the World Hunger Programme.

On the subject of food and nutrition policy a paper by Lowell Lynch, research associate of the Center for International Studies and International Nutrition Policy and Planning Program: "Nutrition-planning methodologies: A comparative review of types and application" is published in the bulletin.

The paper describes and compares the nutrition planning methods elaborated by various researchers and research groups, and how they can be applied. The table on page 2 of the bulletin offers a survey of four types of planning methods, indicating which researchers proposed the methods, the characteristics of the methods, the international institutions which apply the methods, and finally the countries where the programmes are being carried out.

a) "System analysis" approach. This method was elaborated by Alan Berg and Robert Muscat, and improved by James Pines, David T. Call and F. James Levinson. Its characteristics are: Systematic problem-solving process. Analysis of nutrition problems and their causes using readily available data.
Formulation of specific time-phased, costed-out objectives (quantitative, if possible). Selection of interventions using cost-benefit analysis.
Evaluation and reprogramming. Fairly pragmatic approaches.
This method is applied by the World Bank in Colombia and Brazil, and by AID in the Philippines and Indonesia.

b) "Nutrition-based development planning" approach. A method elaborated by Leonard Joy and Philip Payne on behalf of FAO. It is one of the most detailed nutrition-planning methods; according to the authors it is a fundamentally new approach to the problem.
Its characteristics are: Emphasis on malnutrition as an aspect of deprivation syndrome. Development of "functional classifications" and "typical profiles".
Establishment of goals, objectives and targets.
Choice of interventions.
Area-level planning.
Emphasis on elegance and completeness.

The method is applied in the Philippines and Sri Lanka by FAO.

c) Policy formulation approach; a method by Dr. Javier Toro. Its characteristics are: Formulation of food and nutrition policies for inclusion in development plans.
Stimulation of awareness of nutrition factor.
Problem diagnosis, policy definition and programme area determination.
Incorporation of nutrition objectives, policies and programmes in national and sectoral plans.

This is the method used in Latin-America and the Caribbean Islands by the Interagency Regional Programme for the promotion of National Food and Nutrition Policies (PIA/PNAN) since 1971 in co-operation with other international organizations.

d) Community nutrition approach. A method devised by Wilson with the following characteristics: "Bottom-up" as opposed to "top-down" planning. Systematic approach at local level. Community involvement and action encouraged.
Co-operatives formed.
Self-help approach.
Community members serve as extension workers.

The method was applied in Colombia and the Philippines.

In the second part of the review: Country Applications, the author presents examples and results of the application of the individual methods in various developing countries.

In the third part: Comparative analysis of similarities and differences, the author points out that there are numerous similarities in the methods described. Each of them is based on the assumption that malnutrition is a development problem rather than a disease or the result of food deficiency. This leads to the conclusion that it is only possible to explore the causes of malnutrition and solve the problem through a wide range of efforts. The comparative analysis also reveals that although differences exist in the theoretical aspects, they are greatest in the practical application of the methods: "One major way in which the methodologies differ is in the degree of emphasis they place on the various parts of the planning process", the author points out. Considerable differences are also shown with respect to the population group chosen as the basis for analysis. While the "systems" and "community" methodologies concentrate on the group most vulnerable from the point of view of nutrition, the other two planning methods tend to approach the problem on a wider basis.

In a final summary, the author analyses the relationship between the nutrition-planning methods and the governments of the developing countries concerned.

Unexpected benefit from a dairy project

The text of a lecture delivered by Mogens Jul, research associate of the Royal Veterinary and Agricultural University, Copenhagen, Denmark, at the International Congress of Nutrition organized in Rio de Janeiro, August—September 1979, discusses the results of a six-year survey related with a dairy project set up by the government of India. The United Nations Organization assisted this programme through the World Food Programme (WFP) not only at an intellectual level but also by supplying considerable volumes of skimmed milk powder and butter oil. The objectives of the programme were:

1. to make milk available to vulnerable groups;
2. to satisfy consumers' needs and get producers a larger share of prices;
3. to improve productivity of dairy farming;
4. to remove cattle from cities;
5. to form a basis for a national dairy industry.

The paper contains a detailed analysis of urban milk consumption and its effect on the price of milk on the basis of examples from Calcutta, and compares the energy value and protein content of milk with that of other foodstuffs on the basis of local prices. Correlations between consumption and income distribution in the population are discussed with special regard to malnutrition problems in the low income social stratas.

This is followed by interesting information on the situation of dairy farming in India. In the author's words "an uncritical introduction of dairy farming in India could have a catastrophic effect. For example, India has 230 million head of cattle, including buffaloes. If each were to require one third of an acre planted with green fodder, 69 million hectares would be required, plus the land needed to produce feed concentrates. This figure should be compared with the present 75 million hectares planted with food grains in India." The author established the fact that although the programme has not achieved its original aim, it has led to many noteworthy and useful conclusions.

Consultative Group on Maternal and Young Child Nutrition

Under this heading, an account is given, on pages 20—23, of the session held by the Consultative Group in Geneva on 22—23rd February 1979. The following questions appeared on the agenda:

a) Content of background paper for October meeting sponsored by WHO/UNICEF on Infant and Young Child Feeding.

b) Actions recommended to advise mothers with restricted resources who cannot breast-feed.

c) Characteristics of appropriate complementary foods; when and how they should be introduced.

d) Disposition of the Manual of Feeding Infants and Young Children.

Post-Harvest Food Conservation Symposium — Rio de Janeiro

This symposium, organized by Dr. Mogens Jul, was held between 27th August and 1st September 1978 within the framework of the International Nutrition Congress.

In his contribution Dr. Dendy (Tropical Products Institute, London) reminded the participants of the resolution adopted by the general assembly of the United Nations in September 1975: "The further reduction of post-harvest food losses in developing countries should be undertaken as a matter of priority, with a view to reaching at least a 50% reduction by 1985".

He then analysed in detail the various types of post-harvest losses. Grain losses during harvest may be put at 5%; the grains left on the stalks when rice is threshed by hand amount to some 12%, which is completely lost if the straw is burnt, but partly recovered as milk and meat when the stalk is feed.

He also spoke of storage losses caused by rodents, birds and insects. Furthermore, considerable losses are caused by incorrect drying, as well as in the course of milling and husking operations. With rice, washing may result in 2.6% and boiling in 10% losses.

Losses in nutritive value have two characteristic forms, one of which is due to insects and microorganisms. The loss of vitamin and protein content may be considerable. The weight loss in wheat seriously infested by insects may be 1% after 11 weeks of storage, but the amount of flour obtained by 70% milling may be 5% less. A similar degree of infestation may cause a 38% loss of nutritive value after 14 weeks of storage. The other possible cause of losses is the processing technology. Hulling and husking reduce the vitamin B content of grains, while roasting decreases the nutritive value of the proteins. A higher degree of milling increases the concentration of certain antinutritional factors, e.g. of phytic acid in the flour, which in turn inactivates the calcium, iron and zinc in the food. In developed countries where the population has a mixed diet this is of no importance, but under conditions where the nutrition is one-sided it may cause rickets and zinc dwarfess. Dr. Dendy expressed his doubts as to the possibility of achieving the aims set by the general assembly of the United Nations. Dr. Saio (Nat. Food Research Inst., Tokyo) gave an account of storage experiments carried out on soybean at his institute. Storage reduces the quantity and nutritive value of the extracted product. In his opinion the traditional technologies of soybean processing were less drastic than the modern alkali or high temperature treatments, which may lead to lysino-alanine formation and so to protein denaturation.

The role of post-harvest conservation of foods in achieving nutritional goals

In a lecture delivered at the same international nutrition congress in Rio de Janeiro, Ramesh V. Bhat, research associate of the National Institute of Nutrition, Food and Drug Toxicology Research Centre, Indian Council of Medical Research, reported on a considerable increase in millet yield over the last decade as a consequence of breeding millet for productivity, but emphasized the importance of preserving what has been produced. In the past ten years great efforts have been made to assess post-harvest losses. On the basis of the results thus obtained, action programmes have been launched to reduce the qualitative and quantitative losses in various phases of storage and use. According to the 1975 resolution of the UN general assembly, which called for a 50% reduction in harvesting losses by 1985, 40 million tons grain and 5 million tons legumes must be saved. In 1977 FAO allocated 20 million dollars for this purpose. Various organizations and institutions have studied methods of assessing and reducing the losses. In the World Hunger Programme priority is given to post-harvest technologies. The lecturer then presented the results attained by various Indian organizations in the post-harvest conservation of foods in recent years. Both the plans and the methods elaborated include questions of storage, milling, conservation and use. Attention is paid to sanitary aspects, e.g. to diseases caused by mycotoxins produced as a result of inappropriate methods of storage (aflatoxicosis caused more than 100 deaths in the western part of India in 1974—75). High yielding millet varieties often show ergot infection, which may also cause diseases.

Embolism and functional liver disorders may be due to millet seeds mixed with weed-seeds of Crotalaria spp. The danger of poisoning by pesticide residues is also mentioned. Reference is made to simple post-harvest technologies (screening, flotation, washing) with which it is possible to prevent such damage. An interesting method of reducing the water content of standing rice is described. After spraying with a 10% sodium chloride solution the water content of the grain was reduced from 25 to 16% in 48 hours. Paddy treated in this way shows higher resistance to damage by insects during storage. In the case of early and midseason rice varieties the ripening time in itself is a factor in producing better actual yields. The lecturer then spoke of the efficiency of various processing and storage technologies for rice. He then goes on to mention an undesirable factor of the "green revolution", namely, that simultaneously with an increase in grain yields the cultivation of legumes decreases. He then analyses the agronomical and economic reasons for this phenomenon. This is followed by an analysis, based on Indian data, of the cost factors involved in the storage of produce and in the reduction of storage losses. Finally, there is a summary of the most important technological methods of reducing losses, the tasks facing various fields of science, and the efforts of actions aimed at reducing losses, such as "The Green Revolution", "Operation Flood", the "Save Grain Campaign" and the "Grow More Food Campaign".

Symposium on Post-Harvest Technology and World Hunger — Kyoto, Japan

The symposium was organized in Septemper 1978 by Dr. Mogens Jul within the framework of the Fifth International Congress of Food Science and Technology at the request of the UN University World Hunger Programme. The debate was opened by Dr. H. A. B. Parpia, representative of FAO, who emphasized that the problem of hunger could be eased not only by increased food production but also through the improvement of post-harvest technologies, including those of the by-products. The first item of the debate was the problem of harvesting losses.

It is estimated that 10—20% of the grain and 15—40% of the horticultural crops produced is lost. Another important factor is the qualitative loss, i.e. the loss of nutritive value occurring during storage, conveyance and processing. This was followed by a discussion of the relation between modern and traditional storage and processing technologies as reflected in the fundamental socio-economic differences between developed and developing countries.

Utilization of post-harvest residues

This lecture, given by Bharat Bhushan, research associate of the Regional Research Laboratory (Hyderabad, India), was also delivered at the Kyoto conference. The lecturer began with an analysis of the economic development of India, comparing the major characteristics of the colonial era and of the period since the establishment of independence with respect to the agricultural economy. The characteristics of colonial agriculture are grouped in 10 points, three of which refer directly to post-harvest residues and losses: "high post-harvest losses, largely due to inadequate storage facilities and practices"; "Generation of enormous quantities of agricultural residues that are inadequately utilized, either because they are widely dispersed and not readily available, or because there is a lack of technological information on how to use them"; "Inadequate attention to livestock, poultry and other combination farming". The utilization of agricultural residues is considered important by the lecturer from two points of view: "(a) better utilization of existing resources to meet human and animal food needs, and (b) reduction of potential environmental problems caused by such residues". After a summary of the economic and technological problems of by-product utilization, the utilization of residues from rice production is given as an example. The world production of rice is 250 million tons a year. The by-products with this volume are: straw 700—750, husks

70—75, bran 15—20 million tons. The straw is a raw material for cattle feed and paper and cardboard manufacturing, and a subsidiary building material. The quality of the husks depends on the type of rice-mill; they may contain a large quantity of bran and broken grains, in which case they are suitable for feeding purposes. Further, they can be used as fuel in the rice-mill, and as a soil ameliorator in agriculture. The bran is primarily used as feed. India has an important vegetable oil industry; 90,000 tons of germ oil were extracted from the available bran in 1975, utilizing 40—50% of the rice yield. Among the recent possibilities for utilizing rice by-products the author lists a number of up-to-date applications in animal feeding and the chemical industry. In the field of animal feeding alkaline extraction followed by ensiling, ammonification, high pressure treatment and surface fermentation represent a new development. Most of these processes are capital-intensive investments, but ensiling with alkali treatment, for example, can certainly be applied. The possibilities of application in the chemical industry are: the production of active carbon, sodium silicate, drinking water filters, oxalic acid, molecule filters, silicone carbite and silicone tetrachloride. However, it must be taken into consideration that under the present economic conditions in India none of these technologies can be employed. The lecturer then formulates a research programme into the utilization of by-products applicable to the Indian conditions. Finally an evaluation of the Indian problems of utilizing forestry products is presented, in which the economic advantages of "mini paper plants" (5 tons/day) and fatty acid glycerine mini-plant complexes are analysed.

Post-harvest losses: extent of the problem

From a lecture held by Ágide Gorgatti-Netto, Director General, Food Technology Institute, Secretary of Agriculture for the State of São Paolo, Campinas, Brazil (ITAL) at the Kyoto conference.

To begin with, the lecturer points out that while the increase in food production has recently exceeded the growth of the world population (2.5 : 1.9%), it is the developed countries that have primarily contributed to this increase (3.2%); the developing countries have fallen behind, so there is a considerable lack of balance. The other highly important problem of nutrition is the loss that occurs after harvesting for various reasons. In tropical countries with a rainy climate at least half the food produced is spoiled in the period between harvest and consumption. A reduction of this loss by 50% would cover almost 50% of the bread grain import requirements projected for the developing countries in 1985. Its money value is 8 thousand million USA dollars. The lecture contains a detailed assessment of the dimensions and causes of post-harvest losses. The lecturer demonstrates the losses through the example of the 1971 trade in fruit and vegetables on the markets of the two biggest cities in Brazil, using data supplied by the Brazilian Ministry of Agriculture, then he illustrates the national extent of losses in several kinds of fruit as estimated on the basis of the 1973 data. After that, data are presented on the results of post-harvest surveys in various countries. An outline is given of the tasks facing the Brazilian research institutes in the methodological research of loss reduction, followed by an account of the results of some current activities:

1. Storage of maize at farm level. Maize in Brazil is mostly grown on small and medium sized farms. A large proportion of the yield is retained on the farm for feeding purposes. The storage losses are considerable. The losses could best be reduced by the use of storage facilities constructed from sheet metal, but this is an expensive investment. So the development of a cheap means of storage is essential. Storing grain in underground caves is the most ancient method, traditionally employed in Southern Asia and Malta. The storage space is a large, vase-shaped cave lined with straw. The same method is used in Israel, with the difference that polyethylene film is used to line the cave. Good results

were obtained with rice stored for 15 months in this way. According to researchers rodents represent the greatest danger with this method of storage. Hermetic sealing is an essential requirement in underground storage, as this reduces the oxygen and the concentration of carbon dioxide increases in consequence of the respiration of the seeds. Insects thus become inactivated or killed. The destruction of various insects as a function of time, the oxygen and carbon dioxide concentration, and the moisture content of the seed has been studied. The procedure is much more critical from the point of view of protection against fungal infection. It has been demonstrated in an experiment that hulled and disinfected dry maize grains can be successfully stored in caves lined with polyethylene. In a cave $2 \times 1.4 \times 1.5$ m in size, 3 tons maize can be stored. The lecture gives detailed information on how to construct storage-pits and on the result of storage. At a permanent temperature of about 27°C the cost of this storage method is 49 US dollars. The consistency of the stored maize did not change, the germinative ability showed some improvement; the free fatty acid content increased, but this did not affect the quality.

2. Aerobic storage for preservation of soybeans in silos. Soybeans — unlike maize — are produced in Brazil mainly on large-scale farms employing up-to-date agricultural techniques. These farms have storage facilities organized on a co-operative basis and subsidized by the government. Researchers from ITAL studied the methods of storage in cylindrical metal silos. After 6 months of storage they found differences in the quality of soybeans stored in aerated and non-aerated silos, in favour of the former. In the aerated silos the moisture content decreased by 2.7%, and the free fatty acid content was half (0.6%) that in the non-aerated silos.

The author goes on to discuss the advantages of after-ripening fruits refrigerated under controlled conditions.

From the experiments carried out at ITAL the author draws the conclusion that the adaptation of post-harvest technologies from the developed countries in the developing countries is easier than the adaptation of the industrialized agricultural technology itself. He emphasizes the role of government programmes and organs, international research co-operation and final consumer interests in the post-harvest handling of produce.

The remaining pages of the bulletin contain publications of an informative nature, news, and reports of the UNO World Hunger Programme, including a technological description of the manufacturing and qualitative parameters of food-grade groundnut meal. This is a modification of a guideline published in the 1970 PAG (Protein-Calorie Advisory Group of the UN) Guideline No. 2. Among the news and notes, information is found on an International Course in Food Science and Nutrition and on the Nutrition Planning Information Service, and a report on the organization of the UNO World Hunger Programme.

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The supplement to this issue of the bulletin contains papers on the subject of protein-energy requirements under conditions prevailing in developing countries: current knowledge and research needs. In the introduction the crucial questions in this field are defined:

"*a)* What are the relative requirements for dietary protein and energy under the various conditions prevailing for the populations concerned ?

b) Is there enough information to establish safe, practical allowances that are appropriate to the health needs of underprivileged populations ?

c) How valid are extrapolations of protein and energy needs, as determined in healthy subjects with constant and often highly refined diets, to diets of differing physical characteristics, foods, nutrient densities, bulk, and meal frequencies ?

d) Is it necessary to have different allowances for some populations, or are those currently established for normal, healthy populations adequate for all ?"

The supplement contains four papers on the results of research organized by FAO and WHO:

"Protein and energy requirements for body maintenance and healthy organ function."

"The nutritional consequences for acute and chronic infections."

"Nutrient requirements for catch-up growth and tissue repletion."

"Research considerations."

The article found in the Appendix is entitled:

"Standardized criteria for comparative nitrogen balance studies of protein requirements in children and adults in different parts of the world. Consuming diets based on traditional social practices."

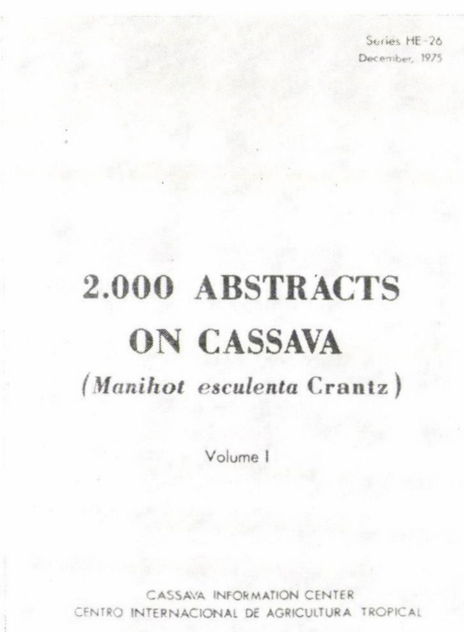
L. GÁSPÁR

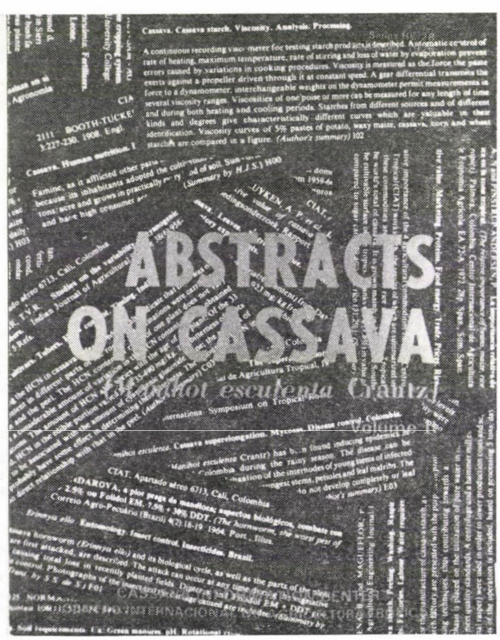
Abstracts on cassava (Manihot esculenta Crantz) I, II. 1975, 1976. Cassava Information Center, Centro Internacional de Agricultura Tropical, Cali, Colombia

The two volumes of abstracts were published by the Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia, as a pioneer enterprise resulting from the work of the Cassava Information Center. Bibliographic data and summaries of 2000 publications in the first volume (584 pages) and 837 publications in the second volume (303 pages) are grouped by subjects on a total of 887 pages. *Manihot esculenta* Crantz is one of the most important cultivated plants in the tropics, and is ranked fifth among the major food-providing plants in the world. This vast bibliographic work is unique of its kind. It may perhaps be intended to serve as a basis for a full comprehensive monograph on the plant, but for cassava specialists the present work will offer the greatest help.

As Fernando Monge, Ph.D., head of the Library and Information Services, writes in the introduction, cassava is the main food plant of nearly 400 million people, so collecting information on it is an important step in the world-wide fight against hunger. The Cassava Information Center has made the collected documents available to anyone interested in the subject: photocopies of any of the publications reviewed will be provided on request.

All that anyone unfamiliar with the subject knows about this starch-containing





tuberous plant is that it is a man-sized perennial ligneous sub-shrub of South-American origin, belonging to the family *Euphorbiaceae*. Since the discovery of America it has spread to almost all tropical countries. It is also known to supply the largest amount of calories on a given area. Its huge, clumpy roots grow to a weight of 5—10 kg. It can be propagated from stem cuttings. Cassava requires a monthly mean temperature of 25—28°C, very little fluctuation in heat and abundant precipitation. The biggest cassava growing countries are: Brazil (about 30 million tons), Thailand, Indonesia, Madagascar, Togo and Malaysia.

The world production of cassava in 1948 was 52.7 million tons on a total area of 6.3 million ha (8.4 ton/ha); in 1964 this figure was 83.2 million tons on 9.0 million ha (9.2 ton/ha) and in 1970 92.2 million tons on 9.8 million ha (9.4 ton/ha). Today it amounts to some 100 million tons a year.

The 2837 abstracts are arranged in the two volumes (2000 + 837) according to identical groups of subjects. Each volume has a table of contents, a subject index and an author index. References are made to nearly 1500 authors, and the complete work contains 327 main entries. The chapters are as follows (the figures in brackets indicate the number of references cited in the given chapter for the two volumes; these figures also show the proportion of space devoted to the various problems and subjects):

1. Botany, taxonomy and geographical distribution (58)
2. Plant anatomy and morphology (39)
3. Plant physiology (37), also:
   Plant development (33)
   Cyanogenesis (19)
   Chemical composition, methodology and analyses (134)
4. Cultivation (194), also:
   Soil, water, climate and fertilization (101)
   Cultivation practices: propagation, planting, weed control and harvesting (159)
   Energy productivity and yields (77)
5. Plant pathology (11), also:
   General descriptive studies (34)
   Bacterioses (54)
   Mycoses (64)
   Viroses (90)
   Mycoplasmal diseases (3)
   Nematodes (9)
6. Pest control and entomology (32), also:
   Injurious insects and their control (95)
   Rodents and other noxious animals (3)
7. Genetics and plant breeding (20), also:
   Breeding, germplasm, varieties and clones, selection (119)
   Cytogenetics (17)
8. Nutrition (24), also:
   Cassava foods and nutritive value (197)
   Nutritive disorders in humans (43)
   Animal feeding (213)
   HCN toxicity and detoxification (44)
9. Processing, products and uses (1), also:
   Cassava starch and its properties (99)
   Uses, industrialization, processing and storage (433)
   Industrial microbiology (27)
10. Economics and development (185)
11. Other associated commodities (3), also:
    Rotational schemes and intercropping (15)
    Descriptive and comparative studies (3)
12. General (103)

As an example of the bibliographic citations let us take a paper published in this journal:

> 0047—1825 Paliwal, G. S. and Kavathekar, A. K.
> Anatomy of vegetative food storage organs. Acta Agronomica Academiae Scientiarum Hungaricae 20 (3—4): 261—270. 1971.
> Engl., Sum. Engl. 9 Refs., Illus.
> Cassava. *Manihot esculenta*. Plant anatomy. Tubers. Roots.

(The key words are usually followed by the abstract formulated by the authors, and less frequently by annotations adopted from other reports.)

To pick out any particular item from this huge bulk of knowledge must necessarily be arbitrary, so I will confine myself to mentioning general information that might be useful to any agriculturist.

The scientific name of cassava (manioca, tapioca) is *Manihot esculenta* Crantz. Its synonym is *M. utilissima* Pohl. The two names were earlier thought to represent two species; the former was described as "sweet" and the latter as "bitter". On the basis of the uniform chromosome number ($2n = 36$) and for other reasons cassava can be regarded as a single species, particularly as the varying HCN content is uniformly characteristic of it. The South American plant is secondarily native to Africa and Indonesia. Its major relatives are: *M. carthagenensis*, *M. dichotoma*, *M. glaziovii* and *M. melanobasis*. These species are of special use in breeding for disease and drought resistance. A wide range of information is also given on other species of minor importance: *M. aesculifolia*, *M. angustiloba*, *M. anisophylla*, *M. auriculata*, *M. brachyloba*, *M. catingae*, *M. chlorosticta*, *M. colimensis*, *M. davisiae*, *M. grahami*, *M. gualanensis*, *M. heptaphylla*, *M. isoloba*, *M. jolyana*, *M. ludibunda*, *M. meridensis*, *M. michaelis*, *M. microcarpa*, *M. olfersiana*, *M. palmata*, *M. piauhyensis*, *M. pohlii*, *M. remotiloba*, *M. rhomboidea*, *M. rubricaulis*, *M. saxicola* and *M. tweedicana*.

In the world variety collections about 2800 varieties of M. esculenta alone are recorded.

The largest number of publications cited were written by researchers in the cassava-growing countries. The most important cassava-growing countries are: in Africa: Angola, the Cameroons, Chad, Congo, Dahomey, Gabon, Ghana, the Ivory Coast, Kenya, the Malagasy Republic, Mozambique, Niger, Nigeria, Reunion Island, Senegal, Sierra Leone, Tanzania, Togo, Uganda and Zanzibar; in Asia: India (Kerala, Madras, Mysore, Tamil Nadu, Travancore), Pakistan and Sri Lanka; in the Far-East: Fiji, Hawaii, Java, Malaysia, the Philippines, Taiwan, Thailand, Vietnam and also Australia, New Zealand, Papua and New Guinea; in Central and South America: Argentina, Brazil, the Caribbean, Columbia, Costa Rica, Cuba, the Dominican Republic, Ecuador, Guatemala, Guyana, Jamaica, Martinique, Mexico, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Surinam, Trinidad and Tobago, and Venezuela.

Cassava supplies twice to three times as many calories per hectare as cereals do. Its average yield varies from 7 to 30 tons/ha depending on the site conditions. It is generally 15—20 tons/ha, though a yield average of 60 tons/ha is not unknown. The fresh tuber contains 1.2—2.1% crude protein, but there are varieties characterized by a crude protein content of 3.7%. The skin of the tuber contains 2—2.8% and the flesh 1—2.4% crude protein.

The fresh leaf contains 6—10% crude protein, which amounts to 20—35% of the dry matter. Proteins of cassava origin are characterized by a very low methionine level, while their lysine contents are high. For this reason the biological value of cassava is 44—57%. With methionine supplement the biological value (BV) rises to 80%.

The water content of the tuber ranges between 45 and 85% depending on the external factors; the accepted value for the dry matter content is about 30%. If the crude fibre, fat, reducing sugar and ash contents are subtracted from this the starch content is about 25%. The gross yield of crude cassava meal is generally 17—19%.

The presence of cyanogenic glycosides, mainly linamarine (93%) and a lesser quantity of lotaustraline (7%), is characteristic of the cassava tuber. Both are decomposed by linamarase to HCN and aglycon. The HCN content of the tuber (mainly found in the skin) is 5—125 ppm depending on the variety. For humans and warm-blooded animals the LD_{min} is generally 1 ppm/kg body weight. In improved varieties with an HCN content in the fresh tuber flesh of below 1 ppm the basic material is considered very sweet, at 1.2 ppm slightly bitter, at 1.2—1.4 ppm bitter, and above 1.4 ppm very bitter. Drying sharply reduces the HCN content, while boiling destroys it almost completely. After 3 hours of boiling HCN can only be demonstrated in traces and does not cause any damage.

The energy value of cassava meal is 60—200 cal/100 g and that of its starch content 360 cal/100 g.

The quality of the starch is equal to that of the best potato starch. The fibre content of cassava is very low and it is very tasty. From 1 ton of tuber 200—250 dry pure starch can be extracted.

From the publications cited the reader learns that even the leaves of the cassava plant can be utilized. When young as much as 500 g/day can be consumed like spinach. The leaf yield is 7—20 thousand kg/ha a year, which corresponds to 500—1400 kg protein. The leaf is particularly rich in carotene, the B-group vitamins and vitamin C as well as in Ca and Fe. Owing to its HCN content it must be boiled for at least 5 minutes. Although the approx. 30% protein content (on a dry matter basis) is characterized by a low methionine level, the amount of lysine is high, while that of tryptophane and other essential amino acids is also satisfactory.

Data could be listed endlessly. Besides information on agrotechnics and particulars about pathology, the bibliography includes subjects such as anther callus, callus induction and regeneration from the shoot apical meristems, neutron induced variegated mutation, etc.

Cassava is certainly a plant of world importance. As a source of starch it is being increasingly imported by the United States and the Western European countries. It serves as a raw material for ethyl alcohol production, soap-making, pottery and the textiles industry, and is used to produce glucose, dextrin, acetone and butyl alcohol. It is a basic material in brewing, yeast production and in factories producing farinaceous foodstuffs. In India, for example, mixed cassava meal (with the addition of 15% groundnut flour, 25% wheat semolina, or 15% chickpea flour, 2.5% casein) has great prospects, as it can be used in the manufacture of macaroni and bread with excellent quality and satisfactory nutritive value. Mixed with soya meal it can be used as a baby food in tropical countries. In addition to all this cassava pellets are an excellent supplement in pig fattening, cattle and calf feeding, and in poultry farming.

As a starch-supplying industrial plant cassava may assume tremendous importance in the future production of fuel of vegetal origin (alcohol).

This great comprehensive bibliographic work is a fine example. Acknowledgement and respect are due to the staff of the Cassava Information Center and the directors of CIAT for this achievement.

L. Gy. Szabó

INDEX

Fasc. 3–4

VARIA

FORUM

CHRONICA

AS I SEE IT ...

LECTIONES

RECENSIONES

INDEX

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